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# THE COSTS OF MONITORING, CONTROL AND SURVEILLANCE OF FISHERIES IN DEVELOPING COUNTRIES

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# THE COSTS OF MONITORING, CONTROL AND SURVEILLANCE OF FISHERIES IN DEVELOPING COUNTRIES

by
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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2002

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## PREPARATION OF THIS DOCUMENT

This preliminary study has three main purposes:

- to demonstrate the wide variation in Monitoring, Control and Surveillance (MCS) costs, reflecting the diversity of fishery governance regimes;
- to provide a basic classification of cost items to focus the fishery manager's attention on the costs associated with MCS and the need for cost-effectiveness; and
- to focus attention on the problems posed by measurement of costs and benefits of MCS and efforts to determine a satisfactory level of MCS.

The information presented in this report is drawn from a number of sources, in particular: project proposals, national fisheries budgets, evaluations of MCS activity. The infinite range of MCS solutions reflects the specific challenges posed by each fishery and the particular legislative and administrative framework of each country. Because of the vast range of MCS systems, the costs presented are illustrative and cannot readily be compared between countries and over time. Often the costs of MCS are not clearly identified within the budgets of the fisheries authorities and the paper suggests approaches to calculating, or extracting such cost information. For comparative purposes information is also presented on MCS activities and their costs in Organization for Economic Co-operation and Development (OECD) countries as the costs of capital equipment and technology is relatively similar and some of the experiences are applicable to developing countries.

Examples of capital and recurrent costs and cost structures are provided. Alternative financing of MCS is briefly described. Because fisheries administrators need to justify MCS expenditures, the difficult question of evaluating the benefits of MCS is also addressed.

Because of lack of information the costs associated with the legal dimensions of MCS and MCS applications under co-management regimes and marine parks are not provided. Costs associated with monitoring health, hygiene, and traceability of fish products are not discussed.

This work was undertaken in the framework of the Regular Programme activity 234P3 – Economic and Social Analysis of Fishery and Aquaculture Policy and Management.

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## ABSTRACT

This report is a preliminary effort to establish the nature and range of costs of monitoring, control and surveillance in developing countries. Definitions of MCS and key terms used are provided and the methodology used in the study is stated. Several of the major factors determining the structure of MCS systems are characterized and the principal capital and recurrent costs identified and quantified, using examples from a range of countries. The problem of estimating the benefits arising from MCS is addressed and approaches to determining and financing an adequate set of MCS activities presented.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ALC | Automatic Location Communicator |
| DFID | Department for International Development (UK) |
| EU | European Union |
| FFA | Forum Fisheries Agency |
| GRP | Fibreglass |
| HACCP | Hazard Analysis Critical Control Point |
| ICES | International Council for the Exploration of the Sea |
| ITQ | Individual transferable quotas |
| LFA | Logical framework approach |
| NOAA | National Oceanic and Atmospheric Administration (USA) |
| NORAD | Norwegian Agency for International development |
| OECD | Organisation for Economic Co-operation and Development |
| OLE | Office of Law Enforcement |
| PNG | Papua New Guinea |
| RIB | Rigid Inflatable Boat |
| SADC | Southern African Development Community |
| SFPA | Scottish Fishery Protection Agency |
| SRFC | Sub-Regional Fisheries Commission |
| SSB | Single Side Band |
| TURF | Traditional User Right Fisheries |
| VHF | Very High Frequency |
| VMS | Vessel Monitoring System |

# 1. CONCEPTS, DEFINITIONS AND METHODOLOGY

## 1.1 Definitions, terminology and methodology

### 1.1.1 MCS terminology

Monitoring, control and surveillance are integral functions of a fisheries management regime. Because of the close linkages between these functions and other fisheries management activities in terms of administration, budgets, capital assets and personnel, the costs of MCS are often difficult to identify. Definitions of MCS provide a basis for identifying costs which can be attributed to MCS activities. Several definitions of MCS are presented below.

**Table 1.1** : Alternative definitions or descriptions of MCS

| Source | Monitoring | Control | Surveillance |
|---|---|---|---|
| FAO Expert Consultation, 1981 | the continuous requirement for the measurement of fishing effort characteristics and resource yields | ***the regulatory conditions under which the exploitation of the resource may be conducted*** | the degree and types of observations required to maintain compliance with the regulatory controls imposed on fishing activities |
| CECAF, 1981[1] | the collection, measurement, and analysis of fishing activity on catch, species composition, effort, discards, and area of operation, *inter alias*, which is necessary for fisheries managers to arrive at management decisions | the specifications of the terms and conditions under which resources can be harvested, and normally contained in national legislation, and provides a basis for which management arrangements are enforced. | the checking and supervision of fishing activity to ensure national legislation and terms and of access and management measures are observed. This activity is critical to ensure that resources are not overexploited, poaching is minimized and management arrangements are implemented. |
| SADC Protocol | the follow-up of a fishery through collection, compilation, analysis, and reporting of information on fishing and related activities, including fish processing, fish trade and aquaculture | the establishment and enforcement of the legal and administrative measures under which living aquatic resources and aquatic ecosystems can be exploited | the checking and supervision of fishing activity to ensure compliance with control measures |

[1] Anon., 1981. Report of the consultation on monitoring, control and surveillance. CECAF/TECH/81/35. Dakar.

While these definitions are broadly similar, there are some essential differences between the latter (SADC) definitions and those of FAO (1981) reflecting some change in the perception of the scope of MCS activities over a 20-year period. FAO (1981) defines 'monitoring[2]' as a 'requirement' while SADC regards it as a set of 'activities'. SADC defines control not merely as the stipulation of the regulatory conditions but includes enforcement activities. Similarly SADC considers surveillance as a checking and supervisory activity rather than as 'observations'. For the purpose of this paper the broader SADC definitions are applied, e.g., expenditures on enforcement and crosschecking and are considered as cost elements in a suite of MCS activities. The focal function of MCS is considered to be 'control' or application of fishery regulations. Some clarification of other concepts and terms used in describing MCS activities is of value when examining the relationships between the costs and the perceived benefits of MCS.

**Enforcement**. To compel observance of the laws. Enforcement includes not only the process of recording violations of the fisheries laws, but also the legal processes and penalties applied. Thus the costs of court actions can be considered as part of the costs of MCS.

**Compliance**. To act in accordance with the regulations. The term 'compliance' is used to describe the extent to which fishermen adhere to the fisheries laws and can be considered as an indicator of effectiveness of the regulatory dimensions of the management regime. Estimates of compliance require an estimate of total violations[3]. This can be made by inference from the results of control activities in relation to a particular violation for a given fishery, or by interviews with the fishermen. Both approaches have weaknesses. Extrapolation from recorded violations assumes that: (a) the targets of inspection/ control were chosen at random; and (b) that all violations existing at the time of boarding/ inspection were detected and recorded. For example, aerial surveillance is unable to detect many types of violations and such records may be difficult to use in calculation of compliance levels. A further problem in calculating compliance in terms of violations detected per inspection is the definition of an 'inspection'. In some cases a cursory glance from an experienced inspector is sufficient, in other cases sampling, or weighing of the catch may be necessary. In other words, the ability of the control authorities to determine the level of compliance varies with the type of violation.

**Detection**. Act of discovering (a fisheries violation). It is not possible to detect all fisheries violations. Thus estimates of compliance are closely linked to the level of detection. Some violations, e.g., unauthorized discarding, may be extremely difficult to detect.

**Deterrence**. To discourage, or hinder. Two forms of deterrence are identified: penalties (e.g., fines, or confiscation of fishing gear); and peer pressure from the fishing community. Deterrence is a function of: (a) the perceived probability of being caught and paying a penalty; (b) the perceived level of the penalty; and (c) peer group pressure, (d) weighed against the perceived benefits accruing from the violation.

### 1.1.2 Terms used in specifying costs

To facilitate discussion of costs a number of terms require description.

---

[2] To the scientific community 'monitoring' means recording catch composition, maturity, condition, and other biological parameters, while to the enforcement officer it means verifying landings, checking the fish hold, or carrying out a pre-trip inspection.

[3] Information on violations may not be compiled in a manner which distinguishes, e.g., a simple administrative omission from a logbook from a suspected deliberate attempt to falsify catch/ landings records. Thus there are numerous problems in using violations as an index of compliance (See Furlong, 1993 for a discussion of the issues involved).

**Capital costs**. The costs of fixed assets such as fisheries inspection offices, surveillance aircraft, or gauges for measuring fish, or nets. These assets usually have a useful life of at least five years. The costs of manpower development (training) and database development (e.g., a fishing vessel register) can also be considered as capital costs.

**Recurrent, or operating costs**. Costs associated with the day-to-day operation of the MCS system. These include salaries, costs of maintenance of the capital assets, communications, travel, fuel and energy.

**Direct and indirect costs**. Direct costs are those which can be clearly and directly attributed to an MCS activity, e.g., the salary of a fisheries inspector fully engaged in MCS duties, or the costs of fuel for the patrol vessel. If, for example, the patrol vessel is owned and operated by the navy, and the fisheries authorities pay only for the fuel, then the additional costs of operating the vessel during fisheries protection duties can be considered as indirect costs of MCS.

**Attributing costs.** In operational and administrative terms MCS activities are often closely linked to other activities of the fisheries authorities. For example, local fisheries officers may have multiple duties some of which are unrelated to MCS activities. Similarly, information collected through MCS activities may be used for both fish stock assessment and control of fishing activities. Determining the proportion of such costs to attribute to MCS depends essentially on the local knowledge of the fisheries administrators.

**Sunk costs**. 'Sunk costs' are costs which cannot be recovered. An example is where the navy is assigned a fisheries protection role. The navy's existing investment in patrol vessels is a 'sunk cost', part of which may be attributed to the capital cost of MCS.

**Opportunity cost.** 'Opportunity costs' offer a means of addressing hidden costs of MCS. For example, if the MCS office occupies a prime waterfront site, and the office next door is rented from the port authority for US$1 000/month, then the 'opportunity cost' of the office space is US$1 000/month.

**Marginal cost.** A 'marginal cost' is the cost of one extra unit. For example, the recurrent cost of one additional patrol vessel may not be the same as a similar existing vessel, as the existing infrastructure, support staff and maintenance capabilities can be shared.

**Shadow costs**. 'Shadow costs' are indicators of likely costs. For example, if a fishing vessel is detained in port for a week, the cost of this detention to the fisherman can be estimated by using the (net) value of the average weekly catch of similar vessels, which may be available from market surveys and landings statistics at the port.

### 1.1.3 Methodology

The infinite range of MCS solutions reflects the specific challenges posed by each fishery and the particular legislative and administrative framework of each country. MCS costs thus vary widely. This initial report has three main purposes:

- to demonstrate the wide variation in MCS costs, reflecting the diversity of fishery governance regimes;
- to provide a basic classification of cost items to focus the fishery manager's attention on the costs associated with MCS and the need for cost-effectiveness; and
- to focus attention on the problems posed by measurement of costs and benefits of MCS.

The information presented in this report is drawn from a number of sources, in particular: project proposals, national fisheries budgets, evaluations of MCS activity, and quotations for goods and

services. Because of the numerous sources of cost information, much of which is from unpublished sources, citations are not always provided. The cost of certain capital assets, such as buildings which house MCS activities, varies considerably, even within a given country, and is considered a to be a purely local dimension of MCS characterized by a need in terms of suitable buildings rather than an MCS item with a particular cost. The costs of much of the capital equipment used for MCS also varies widely as a function of the level of technology used, so that the costs of state of the art computers, radar, or vessel tracking software may be several times the cost of entry level systems.

For these reasons the cost information presented is not readily comparable across time and countries.

Military, police, and coastguard capital assets are frequently deployed for fisheries protection. These assets include patrol vessels and aircraft, buildings, repair and training facilities, communications and intelligence systems. How should capital expenditures on military assets be reflected in an assessment of MCS costs?

The primary function of military assets such as patrol vessels, maritime surveillance aircraft, or maritime traffic intelligence systems is one of national security. Many of these assets will probably exist irrespective of the fisheries protection function carried out by the military. Consequently the capital costs may be regarded as 'sunk' costs and not included in an assessment of capital costs of MCS.

On the other hand a primary task of a coastguard is the enforcement of national legislation on fisheries, shipping, customs, and immigration. A coastguard asset is dedicated to control and enforcement of civil law and can be considered as a capital cost of fisheries protection. The capital cost can be pro-rated to reflect the proportion of the asset's (or the coastguard's) time which is used for fisheries protection.

The operating costs of the military and coastguard may also be pro-rated in terms of the time spent undertaking fisheries protection duties to give estimates of MCS recurrent costs. It is worth noting that some OECD countries charter civilian aircraft rather than make use of defence force aircraft when required to pay the military for fishery surveillance, reflecting the lower cost structure of the private sector.

### 1.2 Determinants of costs

MCS costs are clearly related to the nature of the MCS system. The structure and function of the MCS system is normally determined by four factors: (i) the physical and biological characteristics of the fisheries; (ii) the regulatory framework and management objectives, and more specifically the objects of control; (iii) the assignment of responsibilities for fishery protection among government ministries, or agencies; and (iv) the political/economic profile and relative importance of fisheries within the country.

**Table 1.2** : Examples of the diversity of key determinants of MCS system design

| Characteristics | Examples |
|---|---|
| Scale of fishing grounds | Size of EEZ and continental shelf. Cape Verde – 734 265 $km^2$; Gambia – 19 500 $km^2$; Seychelles – 1.3 million $km^2$; Congo – 41 km coastline; Indonesia – 17 000 islands, 81 000 km coastline, 6 million $km^2$ EEZ & territorial sea. |
| Physical geography | Archipelago, indented coastline, isolation and availability logistic support for fishing fleet (Falklands, Mauritius); non-contiguous zones (South Africa, Malaysia, Angola) |

| | |
|---|---|
| Demography / nature of the fishing industry | Artisanal fishery (Djibouti), industrial fishery (Namibia), mixed industrial/ artisanal (Thailand). Numbers of fishermen: Guinea-Bissau 2 100, Indonesia 4.5 million. Foreign fishing activities: Falklands, Myanmar. |
| Fishing ports | Few ports (Mauritania), Numerous ports/ landing sites ( Philippines) |
| Regulatory framework and fishery management regime | Input controls (Morocco – limited access); Output controls (Mozambique - shrimp; South Africa - pelagics); Legal status of fishing zones (Caspian Sea, South China Sea, high seas enclaves; international lakes and rivers, waters under dispute); Regional cooperation in MCS: Forum Fisheries Agency (South Pacific); Sub-Regional Fisheries Commission (West Africa) |
| Involvement of military | Namibia, Mozambique: low/ negligible. Mauritania, Senegal, Yemen: significant |
| Economic importance of fisheries and value of fish products | Mozambique/ Senegal ≈ 50% of value of exports; Pacific Island nations dependence on tuna; Falkland Islands/ Malvinas; High value products, e.g., abalone, caviar (US$200-1 000/kg) |
| Economic and political strength | Adequate budgetary resources (Brunei Darussalam); Weak government structures and political base (Somalia, Sierra Leone) |
| Other ocean uses and enforcement priorities | Offshore oil (Angola, Venezuela); Tourism (Maldives, Seychelles, Caribbean states); piracy (SE Asia); drugs and arms smuggling; immigration control. |

The importance on fisheries to the island states of the South Pacific means that fisheries protection is discussed at the level of the heads of state ensuring a high degree of political commitment and budgetary support for MCS. Political instability undermines MCS. In Sierra Leone more than 50 percent of the industrial fishing activities are illegal. In Somalia the ransoming of detained foreign fishing vessels by warlords is more akin to piracy, than MCS. The need to ensure the security of offshore oil installations in northern Angola and the Persian Gulf means a high level of maritime patrols, which also help protect the fisheries.

Weak international jurisdiction and control over fisheries in high seas areas and disputed waters[4] can involve substantial political tensions and costs. Numerous Yemeni artisanal vessels were confiscated by Eritrea prior to settlement of their maritime jurisdiction. Disposal of arrested Taiwanese giant clam fishing vessels and crews incurred substantial costs for Papua New Guinea when owners abandoned the vessels, obliging PNG to fly the crews back to Taiwan (Province of China) at state expense. Control of high seas tuna fishing and fishing for Antarctic tooth fish and orange roughy + involve substantial costs for the international community.

The nature of the regulatory framework is fundamental in determining the structure of the MCS system and consequently the costs of MCS. The regulation sets the nature of the control task. While not developing countries, fundamental differences in approach between Norway and the EU (European Union) with regard to the same fisheries illustrate this point.

[4] Lack of agreement on maritime boundaries has led to high MCS costs for countries and high costs for fishermen whose vessels are confiscated. Many maritime boundaries in Southeast Asia have not been settled and there are disputes over large sea areas such as the Bancs des Mascareignes in the Indian Ocean.

**Box 1. Fundamental differences in Norwegian and EU approaches to fishery control**

Both Norwegian and EU objectives of fishery conservation are consistent with international best practice, but there is a fundamental difference in philosophy and in strategic and practical approach. Norway recognizes that control measures which permit excessive fish mortalities are biologically, economically and morally inappropriate. Thus the focus of control is the catch, rather than quantities, or sizes of fish retained on board, or landed, i.e., Norwegian controls are directed essentially at the fishing activities rather than the outputs of fishing. It is prohibited to catch 'illegal fish' (e.g., juveniles) and there is a 'no discards* rule', which is fully supported by all sections of the industry including the fishermen. It is the act of catching (e.g., juvenile fish) which is illegal, effectively obliging fishermen to change fishing grounds if catches contain a high proportion of juveniles.

Discards are seen as an unsustainable, morally unjustified, a signature of irrational resource stewardship, and all possible attempts are made to avoid discards, high grading, and similar practices. Fisheries which have significant discards are seen as ultimately uneconomic in terms of resource utilization. In Norway, there is a direct and potentially measurable relationship between controls and fishing mortality which is not the case in many fisheries.

Under EU regulations it is prohibited to retain on board 'illegal fish' (e.g., juveniles). Thus in the EU the link between controls and fishing mortalities is indirect via landings, and the controls do not prohibit the catching (mortality) of juvenile fish. The indirect nature of this controls-to-resources link in the EU presents numerous methodological problems in assessing both the impact of controls and the state of the fish stocks. The EU argues, with some justification, that it is impossible, or too costly to prevent catching of juveniles

The Norwegian regulations require that the authorities maintain a high level of relatively costly sea inspection to prevent fishing/mortality of juveniles, while the EU can rely on less costly shore inspections to prevent landings of juveniles. Thus the MCS costs are directly related to the nature of the regulations and basic control philosophy involved.

* A similar rule is applied in Namibia.

The costs of control are closely linked to the objects of control, often directly related to the main MCS problem areas.

**Table 1.3** : Main MCS problem areas in SADC countries in 1996

| State | Main MCS problem areas in SADC countries, 1996 |
|---|---|
| Angola | Encroaching on artisanal areas, illegal foreign fishing, mis-reporting catches. |
| Mozambique | Shrimp closed season, gamba vessels entering shrimp grounds, mis-reporting catches. |
| Namibia | Hake area control, by-catch quota control, mis-reporting catches. |
| South Africa | Law and order, by-catch quota control, illegal foreign fishing, mis-reporting catches. |
| (U.R.)Tanzania | Dynamite fishing, environmental degradation, lack of EEZ regime, mis-reporting catches. |

Protection of artisanal fishing grounds from encroachment by industrial vessels is particularly difficult to prevent without either VMS, or a substantial and costly presence by patrol vessels. Several objects of control remain outside the focus of conventional MCS, in particular the scope of

conventional MCS often does not include the fish buyers and processors. However regulation of the entire fish food chain is becoming of increasing importance both to international trade and as a cost effective means of control. Regulatory agencies are requiring increasing precision in traceability of fish products, to ensure food safety[5], fulfil HACCP requirements, meet 'rules of origin' criteria, or make use of ecolabels and quality marks. In many fisheries there is an increasing concentration of fish products to fewer and fewer fish buyers, or processors, making them ideal control points for the flow of fish.

All the SADC countries listed in the above table have problems with mis-reporting of catches. This is largely as a result of use of 'output controls', e.g., catch, or landings quotas, which tend to be inherently more costly than input controls.

**Table 1.4** : A classification of generic fishery management measures/objects of control

| **Input measures/ controls (relatively low cost)** | **Output measures/ controls (relatively high cost)** |
|---|---|
| vessel registration controls/ buy back schemes | catch quotas (by vessel/ company, or ITQ) |
| fishing licence controls (limited access) | landings taxes (on landings/ exports) |
| technology controls (gear) | fish size limitations |
| area controls (protected zones) | purchase/ sales records of processors |
| time controls (seasonal closures, days at sea) | |
| **Outside conventional MCS** | |
| traditional rights (TURFs) | income and company taxes |
| investment /credit controls/incentives/ scrapping schemes | endangered species |
| financial controls (fuel/vessel taxes/subsidies) | |

Some OECD countries target processors focusing on the financial audit trail[6] based on the idea that if the major dealers in undeclared fish are eliminated, then violating fishermen will have no market for their fish. A substantial proportion of the costs of MCS in the USA is attributable to efforts to conserve[7] marine mammals and endangered species rather than directed at commercial fisheries. The growing economic importance of recreational fisheries and marine tourism (e.g., South Africa (the Republic of South Africa), Fiji, Maldives, Mauritius, Caribbean islands) also suggest an increasing MCS focus on non-commercial fisheries.

## 2. CAPITAL COSTS OF COMPONENTS

### 2.1 Buildings and basic infrastructure

The scale of MCS headquarters and field offices varies widely. The offices may be located at the fisheries department, or at naval, or coastguard facilities. In some developing countries the MCS functions are closely linked to the licensing activities and separate offices are not required. A basic office is likely to include the following: operations room fitted with desks, chart table, wall charts, and situation (state) boards, whiteboards, or blackboards; a radio room; several offices for key staff; and possibly a coffee room, storage area and emergency generator. The office may occupy

[5] E.g., absence of contaminants such as pollutants, fish or shellfish toxins, or heavy metals.

[6] The USA's Office of Law Enforcement (NMFS) engages teams of tax investigators to audit the accounts of suspected dealers in 'illegal' or undeclared fish. New Zealand employs specialist accounts investigators as part of its MCS staff.

[7] These include several vast closed areas, closed seasons, gear modifications (e.g., TEDs and for 'dolphin-friendly' tuna), and observer programmes. Key focal objects of the MCS are: whales, turtles, seabirds, billfish, sharks, and other marine mammals, such as Stellar's sea lion.

75-150 $m^2$. The building costs vary widely depending on the cost of labour and the quality of the building materials, but is likely to be in the order of US$200-300 per $m^2$ giving an indicative cost of US$25 000 for a basic MCS office[8] excluding fittings and furnishings which may cost an additional US$5-10 000. Additional facilities may include accommodation for observers, or duty officers if a 24-hour watch is maintained and space to install vessel tracking equipment. If all catch and effort data is logged by the central MCS office then additional computer area will be required. Indicative costs of office equipment and basic requirements of fisheries control officers are tabled in Annex 1.

Field offices will depend on the nature of the fishery and the expectations of the personnel. Rudimentary field offices for artisanal fisheries may be simple tin, or grass-roofed structures of local construction, sufficient to store paper records of control activities, house a radio, and act as a store for fuel, outboard motors, and confiscated fishing gear. Under co-management regimes such fisheries offices may be constructed by the local fishing community. Costs are in the order of US$1-5 000.

Field offices in urban areas are preferably located at the fishing port, or main landing site. These offices may be larger than those at headquarters as secure storage for boats, vehicles, boat-trailers, and other equipment may be required. In addition, a small repair and maintenance workshop for engines, radios and other gear may be of use. Indicative costs vary from US$20-70 000. In practice, a provincial, or district fisheries officer may have multiple functions and be located in the local administrative building, while the local fisheries installations and facilities may be shared between inspection, research and extension staff. If computerized records (e.g., a 'provincial' fishing vessel register, catch, or landings statistics) are maintained at the local office then provision should be made for an air-conditioned office with suitable electric power supply.

## 2.2 Information and communications systems

A range of communications systems are required both within the MCS organization, and between the MCS organization and the fishing vessels, or fishermen. Several information systems are the object of communications within the MCS organization:

(a) vessel and licence data generated usually within the organization as the responsibility of the licensing office;

(b) catch and landings data generated by the fleet, or fishermen. Compilation and analysis may be the function of the fisheries management office and/or the research institute;

(c) resource assessment and management data based partly on the catch/ landings information and supplemented by data from research cruises, economic and market surveys and a range of other sources (e.g., environmental data). The research institute is likely to be responsible; and

(d) information generated by surveillance and inspection activities (e.g., VMS data, records of violations, observer reports) for which the navy, coastguard, or fisheries MCS unit are generally responsible.

[8] €40 000 was budgeted for an 80 $m^2$ (US$575 per $m^2$) headquarters building for Madagascar (1997).

As illustrated in the following figure there is a requirement to coordinate such data systems. Effective coordination can substantially reduce costs.

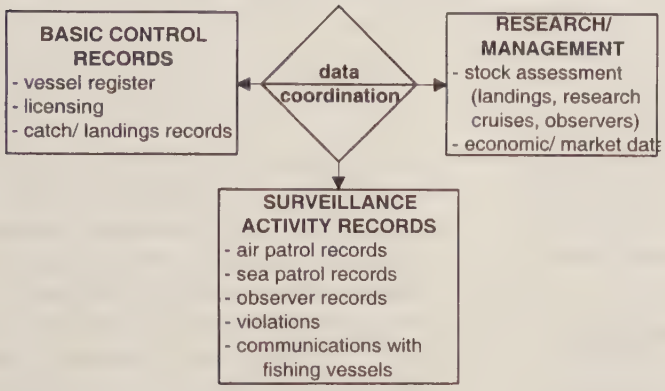


*Figure 1. The overlapping components of data collection*

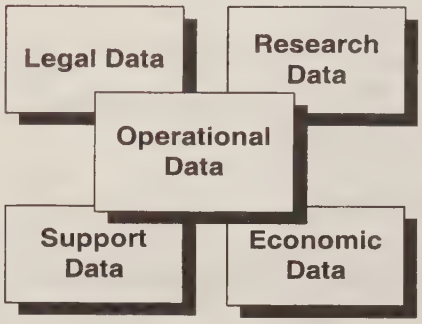


*Figure 2. The overlapping components of a fisheries management information system.*

**Personal contacts**. At the simplest level the communications are through direct talks between fisheries officers and fishermen, or their organizations to discuss fisheries regulations and collect information on the fishing activities. This requires mobility by the field staff using either vehicles, motorcycles, bicycles or boats. Indicative costs of these items are given in Annex 1.

**Radio and telephone**. Basic inter-office voice communication by radio, or telephone, or voice communication with fishery patrols (patrol vessels, aircraft, vehicles) is also a fundamental requirement for effective MCS. The costs of installing telephones often depend on the location of the MCS office and the availability of lines. Connection fees may be in the order of US$100. The cost of HF and VHF radios depend on their power and quality of manufacture, and are in the range of US$250-600 per unit.

### 2.2.1 Database systems

Two different information technology (IT) solutions with quite different cost structures can be envisaged: an integrated database system and several 'stand-alone' databases systems. The integrated solution (e.g., Namibia), whereby licensing information, catch and effort data, information from surveillance and observers, and possibly research data are recorded in a suite of integrated databases. This requires substantial investment not only in equipment but more particularly in programming and is likely to require permanent IT staff. Many OECD countries still retain 'stand-alone' systems, maintaining separate database systems for licensing, catch and effort records, and surveillance/ inspection information.

The following figure shows some of the components of a fisheries information system which addresses some of the operational data requirements and the basic support data (reference tables at left hand side of Figure 3).

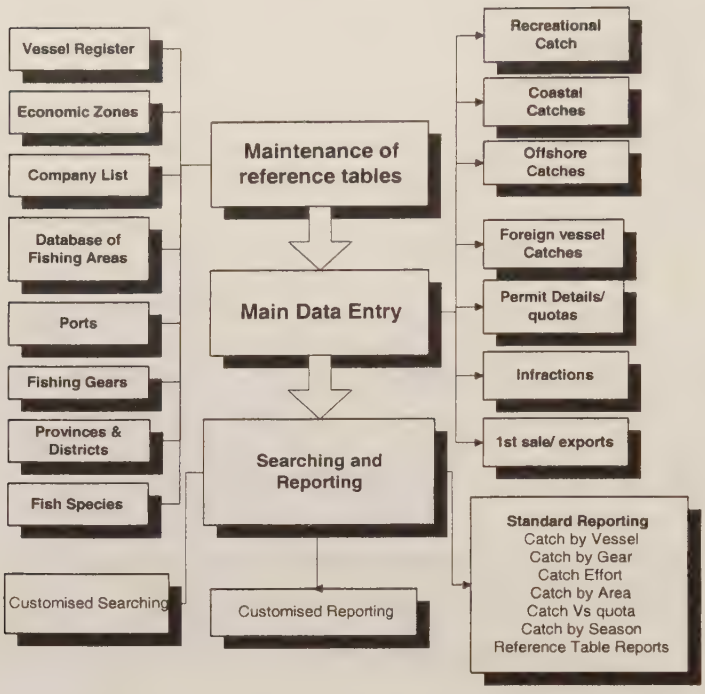


*Figure 3. An overview of the structure of the operational component of a fisheries information system*

Development of simple databases for vessel register, licensing and catch/ landings and effort data using 'off-the-shelf' software and a local software developer is likely to cost in the order of US$30 000 including hardware. A number of countries have developed their 'in-house' staff capabilities and gradually built and modified databases to meet their requirements. However, such efforts are often undermined if non-specialist staff is unable to keep pace with the rapid development of IT. The more integrated and ambitions in scope the more costly the IT system and a highly professional product may cost over US$100 000 and require substantial maintenance. The five data domains listed in Figure 2 are rarely integrated in a single fisheries information system, except perhaps in relation to a specific fishery, where bioeconomic, or other advance models are used.

### 2.2.2 Managing surveillance information

The cost of data systems for surveillance information varies widely as a function of the type and presentation of the information. At the simplest level the records would be manual records of vessel sightings, or boardings logged onshore after a surveillance mission, or a ledger record of the results of regular radio contacts with vessels requiring them to report position, catch, or other information. A far more sophisticated application would be to overlay radar and VMS targets on a graphical display in real time, or near real time (i.e., to identify targets which do not carry VMS by comparing the results of VMS polling with the results of a radar scan). These VMS/ radar applications are often designed for military purposes and may be marketed as part of a proprietary navigation/ defence system for a patrol platform (e.g., aircraft). The cost of such a sophisticated application including the hardware is likely to be in excess of US$0.5 million.

**Smart and expert systems**. The most advanced MCS surveillance data systems have capabilities which allow the operators on patrol vessels, or aircraft to compare real-time (or near real time) vessel distribution with historical records of vessel distribution for the same fishing season, water temperature profile, or weather pattern, thereby helping to optimize the search pattern and costly patrol time. A legislation database may also be linked to the system enabling the fisheries officer to check national, or international regulations, which may apply to a suspected violator (e.g., ICCAT, CCAMLR, CCSBT, or IOTC regulations, or the obligations of the vessel under its flag state legislation). Costs of such systems are not available as they generally evolve internally within the MCS agency over an extended period.

### 2.2.3 International vessel registers

The Forum Fisheries Agency (FFA) in the South Pacific charges an annual registration fee of US$500 per vessel for the approximately 1 200 vessels recorded on the "Regional Register of Foreign Fishing Vessels". The fee is meant to cover the costs of the register (or "record"). The Sub-Regional Fisheries Commission in West Africa has considered a similar scheme as a revenue-generating device to support regional MCS activities.

Attention should be drawn to the difference between a register which is a database, and a Shipping Register. A Shipping Register is a special system that records the ownership of the vessel (and any mortgages), it confers on the vessel nationality and the right to fly the flag. It issues the Certificate of Registry which is necessary if the vessel goes on the high seas or in another country's jurisdiction. It is a property register, is administered by a publicly appointed Registrar and the public are allowed to inspect it (probably they have to pay a fee). Usually the legal formalities are laid out in the Merchant Shipping Laws, but they apply to all vessels including fishing vessels and pleasure craft above a certain size (e.g., 10 m) (usually excluding government vessels).

## 2.3 Vessel monitoring systems (VMS)

A number of developing countries are either already using, or considering the use of VMS[9]. These include: Malaysia, Maldives, Seychelles, Namibia, Mozambique, Morocco, and member states of the Forum Fisheries Agency (FFA) in the South Pacific. The use of VMS is also either advocated, or required on vessels operating under fisheries regimes regulated by international fisheries organizations[10]. A harmonized system is used in the EU, while the USA is moving towards harmonizing a number of different schemes developed independently for various fisheries. Considerations and criteria used to determine if VMS is appropriate include:

- the ecological health of the fishery, or habitat
- low compliance levels
- high compliance cost for non-VMS enforcement
- need for accurate management data
- need data immediately
- geographic distribution of the fishery
- views of industry
- public perception of industry
- safety at sea
- costs of the system

The costs of VMS are decreasing. Current costs (depending on the specifications of the system) are in the order of US$200-350 000 for the base station and software, which receives the satellite information and US$3-5 000 for the transponder (automatic location communicator, or ALC) required on onboard each fishing vessel. As software is a significant part of the VMS package, costs are partly related to labour rates for skilled programmers, e.g., in South Africa a single base station (with a minimal capability installed and configured for 50 vessels) can cost as little as US$60 000. Mozambique is implementing a system with more recent technology costing US$1.3-2 million over a three-year period (including financial charges). Namibia is acquiring a VMS system capable of supporting 400 vessels polled up to 12 times per day for a total cost of approximately US$1 million, which includes VMS data analysis capability on board two patrol vessels and training of staff.

One of the most comprehensive VMS systems is operated by the Forum Fisheries Agency on behalf of its member states in the South Pacific. By sharing the system among 14 countries both the capital and operating costs per country have been greatly reduced. The development cost (capital cost) of building the FFA VMS for approximately 1 200 tuna fishing vessels was US$1.1 million. Each vessel operator must purchase an FFA VMS type-approved Automatic Location Communicator (ALC) which must be fitted to the vessel by an FFA VMS-approved installation agent. The type-approved ALCs typically cost between US$1 500-5 000 each, including installation costs.

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[9] For an overview see: FAO Guidelines for Responsible Fisheries. Fishing Operations. 1. Vessel Monitoring Systems. FAO, Rome. 1998.

[10] E.g., CCAMLR, ICCAT, IOTC, NEAFC, CFP and NAFO.

As VMS is still in the initial stages in many developing countries, some indicative costs from OECD countries are also of relevance. The scale and approximate costs of six stand-alone VMS systems in the USA are given in the following table. Based on these initial VMS costs, the Office of Law Enforcement (NOAA/OLE) estimates that VMS system start-up costs range from US$200 000 for 50 vessels to US$4 million for 5 000 vessels (US$4 000 - 800 per vessel, respectively).

**Table 2.1** : Development and implementation costs of VMS systems in the USA

| Fishery | No. vessels | Cost US$1 000 |
|---|---|---|
| Hawaii pelagic longline | 120 | 1 200 |
| Hawaii lobster | 12 | 120 |
| Guam foreign vessels | 24 | 240 |
| New England scallops/ multispecies | 230 | 1 500 |
| HMS swordfish | 2 | 20 |
| HMS Atlantic pelagic longline | 800 | - |
| Gulf of Mexico shrimp | 12 | 120 |

The EU provides grant support for mandatory VMS installation on all EU vessels over 25 metres to a maximum of 50 percent of vessel expenditure in excess of €2 500 per vessel and not exceeding €3 250 per vessel. Information is not available on the costs of radio-based VMS (i.e., without the use of satellite transmission).

**Radar systems**. Relatively simple low technology coastal radar systems with a 25-50 nm range (Mauritania, Indonesia, and Senegal) cost in the order of US$10 000 per unit including solar panels and antenna tower, but excluding the buildings. Installation in remote areas may add substantially to the costs. HF and VHF radios and additional electric power may also be required for the radar post. Fully equipped radar stations including buildings and HF, VHF radios and GPS were budgeted at approximately US$50 000 each for Madagascar (1997).

## 2.4 Patrol platforms

### 2.4.1 Patrol vessels

**Offshore patrol vessels**. An 'offshore' patrol vessel is considered to be a patrol vessel with the capability to patrol the full extent of a 200-mile EEZ. Such a vessel will normally be at least 30 metres LOA with ability to stay at sea for at least 20 days. Three types of vessels with vastly different costs can be distinguished:

a) naval vessels which have a high speed and are fully equipped for a military role;
b) high speed offshore patrol vessels without military characteristics (e.g., without armour plate, or sophisticated weapons systems); and
c) converted fishing (or similar) vessels.

Each type of vessel has its own merits. New military vessels are clearly the most costly. A new vessel with an anticipated 95 percent use in fisheries protection cost US$25 million in late 2000, while a smaller 28-year-old vessel in good operational condition sold for less than US$75 000 at public auction. The low market value of second-hand patrol vessels must be weighed against the higher maintenance costs of the older vessels. Repair and conversion of a trawler-type vessel for fishery protection cost US$1.5 million for Angola.

**Table 2.2** : Comparison of purchase costs of old and new naval patrol vessels

| Year of construction | Built 1972 | Built 1999/2000 |
|---|---|---|
| Tonnage | 972 GRT | 1 500 GRT |
| Dimensions | 56.2 m (length) x 10.4 x 4.4 | 78.84 m x 14 (beam) x 3.8 |
| Engines | 2 British Polar Diesels ; 4 200 hp; 1 Shaft | 2 X Twin 16 cyl V26 WARTSILA 26 Diesel giving 5 000 Kw at 1 000 RPM, 2 Shafts |
| Horsepower and speed | 4 000 at 17 kts ; 6 750 at 12 kts | 6 000 nm at 15 kts |
| Personnel | 46 ( 5 Officers ) | 44 ( 6 Officers ) |
| Armament | None | 1 x 76mm OTO Melara; 2 x .5" HMG; 4 x GPMG; 2 x 57 mm Rocket Launchers |
| Purchase price in 2000/ 2001 | <US$75 000 | €24.4 million |

Namibia is acquiring a new patrol vessel[11] at a total cost of approximately US$14.6 million including costs of financing and crew training, while in 1996 Mauritania acquired an offshore patrol vessel at a cost of US$10.5 million.

**Coastal patrol vessels.** 'Coastal' patrol vessels are normally vessels of 20-30m with ability to remain at sea for three-ten days. However smaller vessels may be suitable for sheltered areas, archipelagos, or lakes. Capital costs vary widely according to specifications from US$400 000 for 22 m vessels (Indonesia) to a series of three GRP coastal patrol vessels (25 m approx.) purchased by Angola with loan of over US$5 million. Two well-equipped inshore patrol vessels of 16 m and 17 m recently acquired by an OECD country cost US$1.7 million and US$2 million respectively.

A simple and more cost-effective solution in selected fisheries may be to use traditional designs of vessels (e.g., junk, abari, dhow, or local fishing vessel design) as these vessels have the same silhouette, or profile at sea as do the local fishing, or cargo vessels. As any such vessel sighted by an offender is potentially a patrol vessel, the fishing behaviour of the offenders may be influenced by the presence of cargo and fishing vessels. The cost of a 17 m GRP 'abari' design vessel equipped for fisheries protection duty is US$180 000[12]. Confiscated fishing vessels have also been deployed as patrol vessels with some success.

**Open patrol boats.** Small inshore vessel used for patrols in artisanal fisheries, in rivers, lakes and estuaries range in cost from US$1 500-70 000. Indicative costs are given in the following table. Rigid inflatable boats with road trailers offer considerable flexibility for rapid reaction and surprise inspections.

**Table 2.3** : Indicative costs of inshore patrol boats (in US$)

| Inshore patrol vessel type | Indicative operating regime | Cost |
|---|---|---|
| 7-9 m GRP open launch with outboard motors and radio | 3-4 crew, 6 hours autonomy, requires good weather (United Republic of Tanzania) | 5 000 |
| fully equipped 9m rigid inflatable (RIB) with twin 100 hp outboard engines and launching trailer | 4 crew, radar and GPS enables operations at night and in poor weather (Sierra Leone) | 30 000 |
| fully-equipped RIB with vehicle and trailer (OECD) | coastal, estuary, and river patrols | 58 000 |
| 7-9 m GRP with cabin and twin 150 hp inboard engines, radar and radio | 3-4 crew, 6 hours/ day x 150 days/year (Yemen) | 70 000 |

[11] Designed to operate 260 days per year. Main Dimensions: Length over all: 57.60 m, beam 12.50 m, approx. 1 400 GRT, maximum speed 17 knots, cruising speed 4 knots.

[12] Yemen project budget, 1999.

### 2.4.2 Aircraft

Three different types of aircraft used in fisheries protection can be distinguished:

a) relatively small (six-eight passenger) short range aircraft usually used in low level (< 1 000 ft.) maritime surveillance;
b) longer endurance aircraft often used for high flying radar scans and extended low level patrols; and
c) helicopters used for boarding and non-fisheries tasks (e.g., air sea rescue).

**Shorter-range aircraft**. Many aircraft can be fitted with long-range fuel tanks to extend their effective range. However, crew comfort, safety, and fatigue are important considerations, and surveillance flights longer than six hours may become counter-productive in the smaller aircraft, particularly in adverse weather conditions. Among the aircraft commonly deployed in developing countries are: Cessna 172; Cessna 412; BN Islander; Twin Otter (all costing approximately US$2-3 million) and at the more costly end of the scale the Beech craft King Air and Dornier 228 (US$5-6 million range).

**Longer-range aircraft**. Extensively used to patrol the vast EEZs of the South Pacific islands, the Orion aircraft, deployed by the Australian and New Zealand air forces, is an example of a longer range surveillance aircraft. A similar aircraft is used by the Norwegian authorities to patrol their isolated Arctic fisheries. The CASA CN235 (cost US$21.5 million) is also used by many countries for multipurpose maritime patrol.

**Helicopters** are rarely used. Namibia discontinued the use of its helicopter for fisheries protection on the grounds of high costs and inefficiency as a patrol platform. The Norwegian Coast Guard makes successful use of helicopters operated from their larger patrol vessels to board fishing vessels. While the operating cost is high, the helicopters are judged to be safer than rigid inflatables (RIBs) in bad weather and give an added element of surprise.

Further aircraft cost details are provided in Annex 1.

### 2.4.3 Maintenance facilities

This brief overview of MCS costs makes no attempt to estimate the costs the wide range of maintenance facilities which may be required. These include slipways, hangars[13], fuel dumps, airstrips, and electrical and communications workshops. In many cases these facilities are integrated into defence force, or coast guard institutions. Alternatively they are provided through service contracts.

## 2.5 Development of institutions and human resources

This short study cannot adequately address the full extent of MCS institutional development and training. Three topics are selected:

a) Coordination among institutions responsible for MCS at the national level;
b) Practical training of fisheries inspectors and operational personnel; and
c) Systems and software development.

[13] US$700 000 for hangar to support Namibian aerial surveillance (1995).

### 2.5.1 Coordination among institutions responsible for MCS at the national level

The coordination function, *per se*, does not involve a high capital cost. However, the lack of such coordination may incur duplication of costly capital items. The main capital costs result from : (i) preparation of a comprehensive MCS plan for the country; (ii) the time invested by ministers and senior officials in reaching consensus on responsibilities and tasking of MCS (e.g., developing an effective working arrangement between naval and fisheries personnel; and (iii) development of the communications, data handling and operating procedures.

Assuming the use of some external consultants, an initial MCS plan may cost in the order of US$60 000, but clearly depends on the scale of the country and complexity of the MCS task. Further detailed technical plans may be required for different MCS components. It is not possible to place a value on the time of ministers and senior officials. Institutional requirements may include changes to legislation, establishment of inter-ministerial committees; alterations to budgets, staff structures and salary levels, and modifications to financial and court procedures. While the technical dimension of communications and data handling has been discussed above, considerable investment may also be required in establishing effective MCS operating procedures. One approach is to prepare MCS operations manual(s) for a range of personnel: e.g., for at-sea and aerial observers, arresting officers, communications officers, port inspectors, naval and police officers, local co-management agents. An initial set of operations manuals using some external consultancy may cost in the order of US$75 000, but clearly depends on the complexity of the country's MCS tasks and administrative structures.

Further coordination at the regional level is likely to enhance MCS efficiency and effectiveness. Regional MCS projects financed with development assistance exist in: West Africa (SRFC countries); Southern Africa (five SADC countries, €15 million over five years); and in the South Pacific (FFA island countries).

### 2.5.2 Practical training of fisheries inspectors and operational personnel

MCS training usually takes place in a fisheries training school, or naval establishment. Few[14] countries have a dedicated MCS training facility. Training of higher-level officers and provision of specialist courses often takes place either at a regional level, or in developed countries through bilateral arrangements between the fisheries authorities or military.

Estimated training costs (excluding operating costs of vessels and specialized equipment) of fisheries inspectors and observers are US$250 per person/week either in dormitory accommodation, or at sea (estimates from SADC region). The operations manuals mentioned above provide a useful guideline for training programmes, but specialized training materials must also be prepared. Some of these training materials can be adapted from existing material and courses (e.g., West Africa Project AFR/010, FISHCODE Project and various FAO publications, Namibia, Falkland Islands/ Malvinas, and from observer and inspector manuals from various countries). Approximately three-four months of consultancy work may be required to adapt materials and prepare training modules to local requirements (estimated cost US$7-15 000 per month). Overseas (OECD country) university training costs are in the order of US$20-25 000 per person/year, including travel costs. University training in the developing world is likely to cost in the order of US$5 000 per year. Regional training courses for higher level officers cost in the order of US$2 500 per person for a 10-14-day course (estimates from South East Asia).

Training on the introduction of co-management techniques and protection of marine parks and reserves is not widely available. Potential sources of education and training materials include: Zanzibar, Seychelles, Maldives, Caribbean countries, SPC, SECAM, and the Great Barrier Reef

[14] Namibia has a dedicated training facility for fisheries inspectors and observers.

Marine Park Authority. Educational materials for introduction of 'non-coercive' fisheries control through understanding of the tropical coastal ecosystems have been developed in the United Republic of Tanzania and the Republic of the Philippines. Adaptation to local requirements is likely to require skilled translation (text, radio, and video) and low-cost printing (e.g., posters, or teacher's materials for schools). The dividing lines between fisheries co-management (community-based) and MCS remain indistinct. Fisheries officers are tending to move from a largely developmental role to one of fisheries management and require appropriate training in techniques for promoting community participation and awareness, for creation of alternative incomes for those involved in destructive fishing practices, and for establishing community policing and fisheries control mechanisms. The estimated cost of 'in-house' training of extension workers for 10-14 days per year is US$30 per day including transport, food and accommodation, but excluding training materials and training staff time (estimates from East Africa).

MCS tends to generate substantial volumes of data and information. Rationalisation of public service staff levels and the increasing availability of relatively inexpensive computers lead MCS managers to install increasingly sophisticated levels of data management, upon which the MCS system becomes increasingly dependent. From a cost-effectiveness standpoint, some experiences from developing countries offer useful lessons.

Different sections of a fisheries department may develop unrelated databases. For example, the vessel licensing database may be independent of the vessel landings database (North African country and an OECD country). The design of the fisheries information system may be over-ambitious, the complexity leading to delays and excessive costs (Southern African country). The information system may be of a proprietary nature, i.e., the software code remains the property of the software developer rather than the fisheries administration (West African country). Following substantial investment in training in-house computer staff, the skilled staff may be difficult to retain because of high market demand for such computer staff (East African country).

## 3. RECURRENT AND OPERATING COSTS OF COMPONENTS

### 3.1 Personnel

In general, the higher the incomes in a country, the greater will be the proportion of the recurrent MCS costs attributable to staff. Thus personnel costs of the US Coast Guard are approximately 14 percent of the total recurrent budget, while the cost of personnel in Mauritania represents seven percent of patrol vessel operating costs. In Scotland, where fisheries enforcement is operated by a parastatal, personnel costs account for over 50 percent of the recurrent budget, indicative of substantial cost savings on non-personnel operating costs. In Namibia, which is considered to have a strong MCS capability just over 50 percent of the total fisheries administration staff are engaged in fisheries 'operations and surveillance' and a fisheries inspector is paid approximately US$10 000 per year[15].

Salary ranges vary widely with chiefs and directors earning up to eight times the salary of a fisheries field officer, or inspector. Within the Mauritanian navy, the commander of a patrol vessel earns 2.3 times the salary of a seaman, while in Namibia a field officer may earn more than a 'chief' as a result of overtime payments. Patrol vessels may also need more than one crew in order that the vessel remains at sea during several consecutive missions.

To counteract the potential negative effects of low salaries (e.g., corruption) some fisheries administrations offer incentives for the successful arrest and penalization of fisheries offenders. In Mozambique, a proportion of revenues from both licence fees and fines are paid to fisheries inspection staff. Similar schemes exist in several West African countries. Other bonus, or allowance payments may be required for time spent at sea, or on field patrols.

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[15] For details see Annex.

There is a need to continually upgrade the skill of MCS staff. The cost of this training may be five-seven percent of the personnel budget (salaries and benefits). A number of countries appoint honorary fisheries inspectors/ officers using retired officers, village chiefs, or respected fishermen as a low-cost solution for gathering local intelligence on fishing activities.

**Observers.** A distinction must be made between scientific observers and observers with an enforcement role. The scientific observers often have a higher educational level (e.g., qualified biologists) and a higher cost. Three types of fisheries observer programmes exist in the FFA region. A regional observer programme operates under the United States Multilateral Fisheries Treaty for the 33 purse seine fishing vessels fishing in 2001. A sub-regional programme is operated under the Federated States of Micronesia (FSM) Arrangement for 15 locally-based purse seine vessels. Several FFA member countries operate national observer for foreign vessels fishing in their respective EEZs.

The fishing vessel operators fully fund these latter observer programmes as follows: (i) salary for the observers approximately US$25-45 per day, depending on level of experience; (ii) air fares to and from the point of placement (port of boarding/ disembarking) and (iii) insurance while the observer is on board the vessel.

The United States Treaty observer programme covers 20 per cent of all vessel trips, each trip lasting approximately 6-8 weeks. An annual allocation of US$150 000 is budgeted for observer placements each year under this programme, while US$25 000 per year is budgeted for placements under the FSM Arrangement Observer Programme. Under the United States Multilateral Treaty, the United States also finances observer training to the value of approximately US$30 000 per year.

Namibia places two observers from its 200-strong observer corps on board each of the larger fishing vessels. The observers do not have an enforcement role, are not public servants, and are paid approximately US$4 300 per year through an accounting firm contracted to collect the 'observer levy' from the fishing vessel operators. This scheme is now being replaced with a Fisheries Observer Agency and annual salaries will range from US$3 530 to US$7 510 (including benefits). The total annual cost of the revised scheme is estimated at US$1.9 million, financed almost entirely by the industry.

Trained aerial observers in West Africa (regional project) are paid US$30 per mission day and per diem allowance when outside their home country in addition to their regular salaries as national fisheries officers.

### 3.2 Administration and coordination

As the administrative tasks associated with MCS are closely inter-twined with numerous other administrative tasks, the associated costs are difficult to isolate. No attempt is made to identify such costs in this paper because of the wide variety of organizational arrangements within fisheries administrations, and the fact that MCS administrative costs are generally no different from other administrative costs. However the cost implications of certain emerging trends are worth noting:

- the effective use of quotas as a fishery management tool involves substantial costs not only in monitoring landings (catches), but in recording landings (catches) and possibly instituting mechanisms to enable transfers of quotas;
- the recognition that coercive controls may be complemented, or even replaced by co-management or other mechanisms to involve fishermen implies increased costs in decentralization of fisheries management and maintenance of a constructive dialogue with fishermen and concerned stakeholders;
- globalization of trade and the need for product traceability and sanitary control requires increasing coordination between product inspection and control of fishing activities; and

- legal processes may incur substantial costs through use of time by senior staff in formulating legislation, preparing legal documents for courts, or tribunals, and explaining fisheries regulations to fishermen.

### 3.3 Vessel monitoring systems

Operating costs depend both on the type of VMS system and the frequency of usage, or polling of the fishing vessels. The operating cost[16] of the FFA's VMS is approximately US$845 per vessel per year (polling every four hours), equivalent to 0.05 percent of the annual value of production of the targeted tuna fishery, or approximately 0.3 percent of the operating cost of a tuna purse seine vessel operating in the region. Recurrent costs of VMS in the USA are estimated to be about $410 per vessel. The following table illustrates the cost savings in the Hawaiian longline fishery through use of VMS.

**Table 3.1** : Comparative pre- and post-VMS annual control costs of a closed area[17]

| Pre VMS (million US$) costs | | Post VMS (1 000 US$) costs | |
|---|---|---|---|
| 3000 patrol vessel hours / US$1 000/hr | 3.0 | 110 patrol vessel hours | 110 |
| 350 air hours (C-130) / US$7 500/hr | 2.6 | 8 air hours | 60 |
| | | VMS costs | 200 |
| TOTAL | US$5.6 m | TOTAL | 370 |

A total sea area of 160 000 $nm^2$ in two separate zones were closed to the Hawaiian Islands pelagic longline fishery for tuna and swordfish to protect endangered species (monk seal, turtle and albatross) and to reduce, or prevent gear conflicts with the valuable recreational fishery. Between 100-172 longline vessels were involved in the mid-1990s.

### 3.4 Patrol platforms

Maritime patrol platforms are often multi-tasked. Estimates of the costs of fisheries protection can be pro-rated based on the allocation of patrol time by the coast guard, or agency responsible for the patrols. The patrol time of a typical coast guard surveillance platform may be divided among the following peace-time duties:

- enforcement of sovereignty, and search and rescue, both of which always take priority over fisheries tasks;
- fishery and resource surveillance and protection;
- customs controls, immigration checks, and general control of the border and of visiting ships and protection of offshore installations;
- protection of the environment, including oil pollution;
- assistance to the police and other government agencies and supply to isolated islands;
- control of scientific, or exploratory activity;

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[16] FFA, 1998. VMS questions and answers for FFA member countries. GCP/INT/NOR - Field Report C-1/Supp.1. This figure was calculated using a cost-recovery model that takes into account salaries for VMS staff at the FFA Secretariat and in 14 FFA member countries, Inmarsat messaging costs for six reports per day per vessel (based on 1 000 vessels), communications costs from the Land Earth Station to the VMS hub-site at the FFA Secretariat, communication costs from the VMS hub-site to each FFA member country VMS site, replacement costs for the VMS hardware at the VMS hub-site and in 14 FFA member countries, and a service level agreement contract costs with the VMS contractor.

[17] Sources: Herman, N., Coast Guard Briefing; McKinney, D.A., 1997. Hawaii fishing vessel monitoring system. Report of the pilot project. OE NMFS.

- general safety at sea, vessel seaworthiness, reporting and elimination of drifting objects, and the protection of undersea cables.

### 3.4.1 Patrol vessels

**Offshore patrol vessels.** The operation of offshore patrol vessels is probably the single greatest cost item for fisheries MCS. A useful means of establishing the range of operating costs is through examination of the costs of patrol vessel charters.

The Falkland Islands Government charters two fishery protection vessels from the private sector, the largest of which is a modern 76m (LOA) vessel suitable for the rough temperate waters of the Southern Atlantic ranging from the Falklands to South Georgia. The annual cost for both patrol vessels is US$5.46 million (2001), or US$7 500 per vessel per day, of which fuel can account for approximately US$1 150 per day. In the recent past a long-term (two-three year) charter for a 65 m (LOA) patrol vessel cost approximately US$4 600 per day. Despite being operated by the private sector one vessel is armed. General charter conditions allow for 20 days maintenance per annum. Additional 'downtime' is not compensated. Vessels operate on fortnightly patrols; 13 days at sea, followed by one-two days in port. One vessel also undertakes fisheries research.

South Africa has chartered fully manned 'trawler type' vessels (Kuswags, 29 m) for fisheries and environmental protection at a daily rate of US$815 (1996), while Namibia has chartered[18] a fisheries patrol vessel at US$650 000 per year with fuel paid by charterer. Norway charters commercial fishing vessels for approximately US$1 400/day to identify and police closed areas in the Barents Sea. The Scottish Fishery Protection Agency avails of the services of Royal (UK) Navy minesweepers or similar military patrol vessels at a cost of US$7 500 per day (1997), while the estimated daily operating costs of South African military patrol vessels ranges from US$1 250 (400 GRT minesweeper) to US$2 970 per day (Strike craft) in 1996.

The Pacific Patrol Boat Programme (currently 23 patrol boats operating in 12 FFA member countries) has been reviewed[19] by the Australian Defence Force. Some caution must be exercised in relation to estimates of the cost of patrols by naval vessels. In an OECD country, where 90 percent of the naval activities and maritime patrols are fishery related, the navy estimates the average direct operating cost per vessel patrol day at US$7 500 (65 m minesweeper). However, this estimate excludes depreciation of vessels, paying multiple patrol vessel crews, costs of maintenance staff, training, and administrative overheads. If 90 percent of all recurrent costs are allocated to the fisheries task, the total cost per patrol day is US$27 600. In this case personnel account for 59 percent of costs, maintenance 39 percent, and fuel seven percent. Standardized operating costs of different US Coast Guard cutters are given in Annex 1.

Several mechanisms can be introduced to reduce the high costs of sea patrols. Rather than being obliged to escort an offending vessel to port, which incurs costs to both the fisherman and the patrol vessel, skippers (of national vessels) may be given the opportunity to sign an admission of a violation. If regulations indicate that certain fishing gears cannot be left unattended (e.g., longlines, or gill nets) the officer on the patrol vessel may be authorized to haul and confiscate the unattended gear. A checkpoint system (entry/exit corridors) for vessels entering, or leaving designated fishing zones is becoming well-accepted by fishermen and may offer a substantial cost saving for sea controls.

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[18] Patrol vessel Battle Cuito Cuanavale in 1996.

[19] Reports of these reviews not sighted. See: Bergin, A. 1994.

**Table 3.2** : A percentage breakdown of estimated operating costs (excluding personnel) on a range of Mauritanian fishery patrol vessels (2001)

| Cost item | Inshore (10 m) | Coastal (18 m) | Offshore (>25 m) |
|---|---|---|---|
| Fuel and oil | 22 | 18 | 39 |
| Local operating expenses | 67 | 44 | 19 |
| Insurance | | 14 | 9 |
| Repair and maintenance | 11 | 18 | 33 |
| Classification | | 6 | 0.2 |
| Total relative costs - inshore = 1 | 1 | 6 | 27 |

**Coastal and inshore patrol vessels.** The smaller vessels offer a number of cost advantages to the fishery administration. Spare parts and repairs may be available locally avoiding costly trips to foreign dry docks, or delays due to shortage of foreign exchange. A somewhat less skilled and less costly crew may be adequate. Actual operating costs will vary widely in accordance with local wage rates and fuel costs and are not detailed in this report.

**Fleet support vessels.** To remain on the fishing grounds for extended periods many fleets operating in developing countries are supplied with fuel and deliver fish to transport vessels. These reefer, bunker, or fresh fish collection vessels can serve as a cost effective control point by placing fisheries inspectors permanently on board, or by requiring such vessels to moor and operate at designated locations. Control of these vessels, which may require international collaboration, can also mean additional public revenues from fuel taxes and import of supplies.

### 3.4.2 Aircraft

The following table details charter, or operating costs for maritime patrol aircraft in recent years. Accommodation for crews of leased /chartered aircraft can add substantially to the daily cost if the aircraft is operating from several different base airports.

**Table 3.3** : Examples of hourly costs for aircraft used for fisheries patrols (in US$/ hour)

| Aircraft | Details | Charter | Total |
|---|---|---|---|
| Twin Otter DHC-6 | Senegal Armée de l'Air | 720 | 870 |
| Dornier 228 | Cape Verde Guarda Costeira | 700 | 750 |
| Y12 | Mauritanian air force | 500 | |
| Cessna 406 | Southern Africa | | 705 |
| BN Defender Islander (2) | Falkland Islands government (760 hours/ yr) | 770 | 770 |
| BN Islander ( Feb. 2000) | West Africa/ Luxembourg company | 1 000 | |
| Dornier (civilian) | Norway chartered 450 hours in 1999 | 1 385 | |
| P3-Orion | Norwegian air force aircraft (multipurpose patrol) | | 7 600 |

In Namibia (1996) a Cessna 406 was operated for US$275 per hour excluding crew salaries while a helicopter, operated at US$2 280 per hour, was not considered a cost effective solution for fisheries protection. Annual operating cost of the Norwegian Coastguard's six helicopters is in the order of

US$5.2 million. Because of the high maintenance requirements, only 50 percent of the helicopters are normally operational.

The estimated operating cost of the CASA aircraft (OECD country) is US$945 per hour, excluding the cost of personnel, which, if included, almost double this cost to US$1 708 per hour. Two such aircraft operated by the air force require up to 30 staff, including three air crews (five-six per crew including photographer), a maintenance team, air traffic/ runway control, and manning of the operations room.

### 3.5 Costs to fishermen

MCS imposes both direct and indirect costs on the fishermen, or vessel operators. Every restriction on the fisherman's activity incurs a cost, i.e., compliance with a regulation is likely to incur a cost to the fisherman. While no empirical information is available on the costs incurred by fishermen in developing countries as a result of control measures, some consideration of the costs of MCS to the fishermen is of value. If the costs of compliance are high then violations may also be high. Assessment of these costs can be carried out by consultation with the fishermen, or by specific studies[20].

Several different types of costs can readily be identified. Direct costs occur if new regulations require gear alterations (e.g., if a larger mesh size is necessary). Similarly, installation of VMS may incur capital costs of over US$5 000 per vessel and recurrent costs of US$400-1 000 per vessel per year. Loss of fishing time and fish quality through delays and inspections, fines, forfeitures[21], and legal costs impose a financial burden on the vessel operator. There are costs associated with maintenance of records required for control and reporting purposes, and increasingly complex regulations require vessel operators to invest time in their interpretation and discussion with authorities. At the artisanal level negotiation of co-management arrangements may require lengthy discussions and local meetings.

Indirect costs accrue as fishermen expend substantial time and effort searching for fish concentrations outside closed areas, or to avoid prohibited by-catch. Anthropological studies[22] indicate several less-evident social costs as fishermen monitor each other's behaviour, thus leading to social tensions particularly in small communities. Other hidden costs result from uncertainty regarding constantly changing regulations and the consequent inability to plan the fishing business, both in operational and financial terms.

Fisheries administrations rarely attempt to recover, or internalize direct control costs, which means the fishermen have little concern over the efficiency of control activities. Indicators[23] of impact for fisheries control need to be developed as neither the direct costs of control, nor the costs to the fishermen of the fisheries management measures and controls have been a major focus of attention outside of politically-charged fishermen/ fishery administration discussion.

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[20] US fishery management plans require that assessments of the economic impact of regulations be made.

[21] While fines and forfeitures can be considered as costs to the fisherman, in economic terms they are transfers from the offender to the public purse and not social costs.

[22] Pers. comm. Jentoft, S. and K. Mikalsen.

[23] See Summa, H., 2000. Cost effectiveness of monitoring tools. Int. Conf. on fisheries MCS, Brussels. The focus of many monitoring indices is on the mechanics of control rather than on the evaluation of impacts. See also Section 5.

## 3.6 Distribution of costs by activity

### 3.6.1 Total MCS costs

The following table provides estimates of total costs of MCS in relation to selected indicators in the SADC region. Mauritania spends approximately two percent of gross revenue[24] from fisheries on fisheries protection. A budget of US$16.5 was submitted for the 1998-2001 period.

**Table 3.4** : Estimated recurrent costs of MCS in the SADC region in 1994

| | Angola | Mozambique | Namibia | (U.R.)Tanzania[a] | South Africa |
|---|---|---|---|---|---|
| Value of landings (million US$) | 50 | 93 | 333 | 38 | 513 |
| Estimated cost[b] of MCS (1 000 US$) | 30 | 282 | 8 244 | 103 | 9 725 |
| MCS as % value of landings | 0.1% | 0.3% | 2.5% | 0.3% | 1.9% |
| MCS as % of value of exports | 0.1% | 0.4% | 2.5% | 0.7% | 3.6% |
| MCS costs US$ per 1000 km$^2$ of EEZ | 50 | 501 | 16 357 | 463 | 9 262 |
| MCS costs US$ per km of coastline | 18 | 101 | 5 496 | 72 | 3 377 |

*Source: EBCD/ GOPA, 1996. a) Refers to marine production/ MCS only for both United Republic of Tanzania mainland and Zanzibar. b) Costs exclude donor contributions.*

Some comparison between developing and OECD countries regarding the scale and distribution of MCS costs is of relevance. The total recurrent expenditure on United States fisheries management is in the order of 1 billion[25], of which the expenditures on control and enforcement are approximately 50 percent-60 percent, or 14 percent of the value of United States commercial landings. While this percentage may appear high in comparison to other regimes, it makes no allowance for the considerable value of the United States recreational fisheries[26], or the high value the United States public places on endangered species and marine habitats such as coral reefs. A recent study of five OECD countries shows that MCS costs ranged from 1 - 11 percent of the estimated value of the catch taken in the EEZ (average 2.6 percent). As one of the few specialized fishery protection agencies the breakdown of SFPA cost is of interest (following table).

[24] Including very substantial access payment by the EU.

[25] Including the NMFS and CG budgets and allowing some provision for state expenditures. A similar figure is given by Andersen, et al., citing Milazzo of NMFS, Silver Spring.

[26] Some recreational fisheries harvest greater quantities than the commercial fisheries. Examples include: striped bass, dolphin fish, yellow fin, and king mackerel, while summer flounder and bluefish recreational catches are also of considerable significance.

**Table 3.5** : Breakdown of MCS operating expenditures in different administrations (percent total expenditure)

| Expenditure item | Mauritania % (excluding personnel costs) | Madagascar % (incl. Personnel costs) | Scotland % (including personnel costs) | Average of five OECD countries (incl. personnel) |
|---|---|---|---|---|
| HQ/ administration | 17 | 22 | 13 | 10 |
| Field offices | 8 (3 offices) | 8 | 23 (coastal/ports) | 25(coastal) |
| Communication centres | 1 | | | |
| Factory controls | 0.04 | | | |
| Patrol vessels | 62 | 32 | 49 | 51 |
| Patrol aircraft | 12 | 16 | 11 | 13 |
| Radar stations | 1 (3 stations) | 17 | | |
| Legal actions | | | 2 | |
| Other | | 6 | 1 | |

*Sources: Mauritania. Budget information, 2000; Madagascar. project document, 1997; Scotland. Accounts, Scottish Fishery Protection Agency (1998-99).*

Using a fleet comprising both military and chartered trawler-type vessels the Norwegian Coast Guard activities account for over 85 percent of Norway's MCS costs (total recurrent MCS costs were approximately US$79 million in 1999). Almost all fish is sold through the sales organizations (owned by the fishermen). The obligation of the sales organizations to provide landings information to the fisheries authorities incurs both capital and recurrent costs. Approximately nine percent of the Directorate's staff is engaged in MCS-related tasks.

**Table 3.6** : Breakdown of Norwegian MCS costs by institution, 1999 (percent)

| | |
|---|---|
| Directorate of Fisheries | 10.7 |
| Coast Guard | 86.6 |
| Prosecutor/ judicial offices | 0.4 |
| Fish sales organizations | 2.1 |
| Fishermen's organizations | 0.3 |

**Table 3.7**: A breakdown of MCS costs by activity in an OECD country, 1999 (percent)

| | Offshore | Inshore/ coastal | Coordination/ administration | Total |
|---|---|---|---|---|
| Aerial surveillance | 22 | | | 12 |
| Other operations | 13 | 14 | 21 | 15 |
| Depreciation | 11 | 11 | 10 | 11 |
| Staff costs | 53 | 75 | 69 | 62 |
| Total | 55 | 32 | 13 | |

### 3.6.2 Artisanal co-management

Developing co-management regimes, which harmonize the traditional approaches to fisheries management with modern fisheries legislation, is a lengthy process involving training of extension agents and fisheries officers in new approaches such as participatory processes. Devolution of selected fisheries management functions to provincial, district, or community level takes time and effort and may include awareness campaigns, efforts to curtail, or eliminate destructive fishing practices and create alternative employment, and to develop marine parks, or marine protected areas.

### 3.6.3 International agreements

Establishing and maintaining international fisheries agreements and organizations incurs costs related to attendance at meetings, annual contributions, possible changes in legislation, and enforcement obligations. However, the history[27] of the Fisheries Enforcement Agreement between the United States and Canada shows how the absence of an agreement on fisheries enforcement can result in substantial costs to fishermen, to the fisheries administrations, and in terms of a loss of political harmony.

Examples of agreements directly related to MCS include: the Nauru, Niue, and Tonga/Tuvalu agreements in the South Pacific; hot pursuit agreements in the area of the Sub-Regional Fisheries Commission in West Africa (from north to south: Mauritania, Senegal, Cape Verde, the Gambia, Guinea-Bissau and Guinea), the recent SADC Protocol on Fisheries (Southern Africa and some Indian Ocean countries).

## 4. PAYING FOR MCS

### 4.1 Alternative sources of finance for MCS

In developing countries, MCS activities are typically financed from five alternative sources:

a) from the government's recurrent, or investment budget (treasury);
b) through a fisheries sector fund into which registration fees, licence fees, royalties, fines, or revenue from fishing access agreements may be deposited;
c) by direct contributions from the fishing industry;
d) commercial loans and contracts; or
e) through development assistance.

**Treasury.** A developing country's finance ministry may be justifiably concerned about the high costs of surveillance and likely to make strong arguments for sharing MCS patrol platforms between military and civilian users. The option of creating a either a private sector, or dedicated sea fisheries protection service was carefully considered and rejected in one OECD country. The reasons included:

- economies of scale and the multi-tasked nature of a single maritime surveillance agency can justify the high capital expenditure;
- other dedicated requirements which would also be necessary (e.g., for air/sea rescue, customs, immigration) if a dedicated fisheries maritime surveillance service was established;
- synergies in communications, technology, security, and coordination;
- shortages of skilled and highly specialized personnel at a national level; and
- the relatively unproductive peacetime role of a navy and air force which will exist even in the absence of a fishery protection role.

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[27] Kraniotis, P., 1994. The Fisheries Agreement between the United States and Canada. OECD, Paris, 1994

**Sector revenues.** Fishermen pay for MCS directly through a range of fees, taxes and other levies (e.g., fishing licence fees). They also pay for MCS through fines for violations. However, fishery protection will not pay for itself through revenues from fines. Experience from the Falkland Islands (approximately 160 large vessels operating in the 200-mile zone) shows that, providing the fishery protection operation is efficient, and the chances of being caught are high, and fines are set at a level which has deterrent value, then in the long-term fines may not amount to more than five percent of costs. In OECD countries, direct revenues, e.g., from licences and fines, rarely exceed the costs of MCS activities. Many developing countries operate 'fisheries funds' under the direct control of the fisheries authorities. Revenues from the industry are deposited and may be used to supplement or finance MCS expenditures and offer fisheries authorities some financial independence.

**Direct contributions.** Examples include the financing of VMS installation and operating charges by the fishing vessel operators. In Mozambique, one of the shrimp fishing companies has provided a trawler to patrol the grounds during the closed season. In Namibia, the industry pays a specific fee for observer services. A wide range of reports (logbooks, radio, sales, VMS) which may be required by the fisheries authorities are also financed by the industry.

**Commercial loans and contracts.** Mozambique is financing a VMS system using commercial credit arranged by the system supplier. Sierra Leone financed fishery protection provided by the private sector (early 1990s) by contracting for a share in revenues from licences and fines. However, revenue estimates were over-optimistic and failure to pay fines on a timely basis undermined the arrangement[28].

### 4.2 Development assistance

The South Pacific (FFA area) provides an example of how MCS costs are shared between coastal (developing) states, distant-water fishing nations and development assistance. Australia provides 400 hours of aerial surveillance per year (P3C Orion), New Zealand 270 hours (P3C Orion) and France/New Caledonia 30 hours (Falcon 200 Guardian).

**Table 4.1** : Costs of regional MCS activities in the South Pacific, FFA area. (US$1 000)

| | Pacific Islands countries | Distant-water fishing nations | Development assistance* |
|---|---|---|---|
| VMS installation (capital investment) | | 5 000 | |
| Patrol vessels/ aircraft (capital investment) | | | 1 200 |
| VMS operation | 350 | 850 | |
| Aerial surveillance | | | 5 000 |
| Sea-going surveillance | 3 000 | | 3 000 |
| Observer programme | 1 000 | 250 | 250 |
| Regional register | 20 | 500 | |
| Data collection | 600 | 400 | 40 |

*Source: Estimates from Van Santen and Muller, 2000. *Mainly from EU, Australia and New Zealand.*

As indicated in the following table (not exhaustive), numerous countries have benefited from development assistance for MCS.

[28] Sierra Fishing Company Limited, 1994. Report of the investigating committee into the activities of Sierra Fishing Company Limited for the period 1989 to 1993. Internal report, April 1994.

**Table 4.2** : Examples of development assistance for MCS

| Donor(s) | Recipient(s) | Nature |
|---|---|---|
| FAO/ FISHCODE (NORAD) | South Asia, Southeast Asia, Indian Ocean | technical and legal advice, training, international cooperation |
| EU | SADC countries, COI countries, Yemen, Madagascar | Hardware, information systems, training, international coordination |
| Australia, New Zealand, EU, France | Pacific Islands Countries | VMS, patrol vessels, aerial surveillance |
| Germany | Mauritania | hardware, software, technical assistance, patrol vessels |
| Luxembourg, Canada | Sub-Regional Fisheries Commission countries | aerial surveillance, installations and technical assistance |
| UK/ DFID | SADC, Sierra Leone | inshore patrol vessels (RIBs) |
| France | Indian Ocean, Senegal, Angola, Pacific Islands | wide spectrum of activities |
| Norway | Namibia, Mozambique | Training, technical assistance, patrol vessel |
| Japan | Yemen | patrol vessels |
| Sweden | Angola | technical assistance, information systems |

Note: Examples only, list not exhaustive and excluding linkages with fishing access agreements.

### 4.3 Reducing costs

As surveillance patrols are the major MCS cost item, savings in patrol costs are a key focus and cost reduction is a major argument for sharing hardware and coordinating field operations between the various stakeholders involved in maritime surveillance (e.g., fisheries, navy, customs, and air/sea rescue). The savings can be achieved both by sharing and increasing the effectiveness of the patrol platforms:

- through use of VMS (in the longer-term, as VMS may actually increase costs in the short-term);
- through increased use of night boardings to maximize boardings per patrol day (weather and safety permitting);
- use of multiple RIBs in areas of fleet concentration, again to maximize boardings per patrol day (weather and safety permitting);
- possible reductions in escort duties i.e., if the vessel operator signs an 'admission of violation' it may be possible[29] to avoid escorting to port;
- use of corridors for entry and exit of foreign vessels from the EEZ and transiting of closed areas/ EEZs, i.e., if VMS 'non-fishing' signatures are insufficiently robust for control purposes;
- reduction in patrols during times of bad weather when boardings are impossible; and
- chartering additional patrol vessels for 'critical' periods, e.g., a closed season, rather than investing in an additional patrol vessel.

A second major argument is whether to charter or purchase patrol vessels or surveillance aircraft.

[29] Some amendments to the legislation are likely to be required.

**Table 4.3** : Charter, or purchase patrol platforms?

| In favour of chartering | Against chartering |
|---|---|
| Avoids capital investment.<br>Avoids senior officials spending time and effort to maintain and manage vessels and aircraft. | 'In-house' or national capabilities may not be developed. However, this could be avoided by training components in the charter agreement. |
| Experience indicates that private companies may operate patrol platforms more cost-effectively than public institutions. | Recurrent costs may be relatively high.<br>The market for patrol vessels is relatively limited (i.e., there may be few experienced companies which can charter suitable patrol vessels). |
| Allows the fisheries administrations to test various types and sizes of patrol vessels. | May not give adequate operational control over the patrol platform. May be difficult to use chartered platforms for non-fisheries tasks (e.g., related to national security). |
| The surveillance platform may only be required 'part-time'. | If owned the patrol platform must be maintained and crewed on a full-time basis. |

South Africa, Canada and Norway charter civilian aircraft for surveillance. Operating costs of chartered Norwegian patrol vessels are significantly less than those operated by the Coast Guard (even allowing for the different types of vessels as the cost differential is largely attributable to different personnel costs). Where government structures are weak, chartering offers a practical solution to surveillance. To defray costs and provide a community and government service, patrol craft may also be used to carry passengers to isolated outposts.

## 5. APPROACHES TO ESTIMATING BENEFITS

The MCS manager has limited resources in terms of manpower, funds and capital assets. A critical question facing the manager is how to distribute these resources among the various MCS tasks such as information collection, port controls, sea patrols, and legal activities. This requires some means of assessing the benefits of different combinations of MCS activities. Estimating the benefits accruing from the MCS efforts is one of the most difficult questions facing the MCS manager, one which neither developed, nor developing countries have successfully addressed. The following sections offer some guidance on how to approach these issues, specifically:

a) How can the optimum suite of MCS measures be established?
b) how can the benefits of an existing suite of MCS measures be estimated, and
c) how can the effect of proposed MCS changes be measured?

### 5.1 Seeking an optimum suite of MCS activities

The costs of MCS activities, or sets of complementary or interdependent MCS activities, need to be assessed in relation to the results. The single most important 'result' is the biological state of the fish stocks. Where possible there should be a direct and potentially measurable relationship between controls and fishing mortality. This relationship does not exist in many fisheries and results in uncertainty. A 'decision analysis' explicitly recognizes uncertainty and can offer a useful step-by-step approach if the MCS objectives are clear.

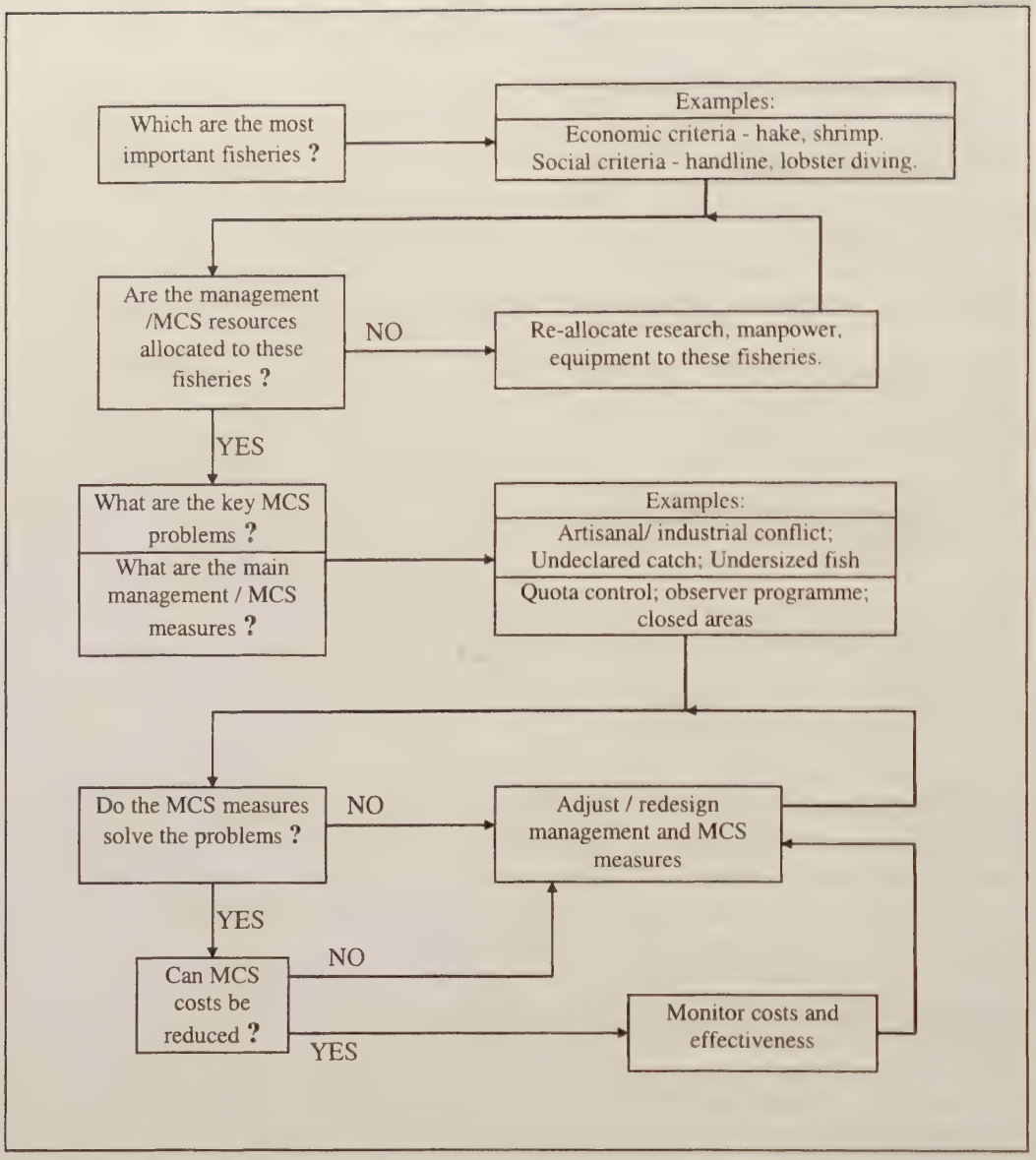


*Figure 4. Decision tree for identifying a suite of effective MCS measures*

Within this decision framework several[30] 'management tools', or analytical methodologies can be directed at resolving the multi-dimensional problem of assessing control strategies. These include: cost/ benefit analysis; cost-effectiveness analysis; critical path analysis; HACCP; LFA and SWOT, some of which are briefly discussed below.

**Cost-benefit analysis** suffers from difficulty in clearly establishing and valuing the benefits of the MCS activities, even though the costs of MCS can readily be recorded, or calculated. As MCS activities are highly interdependent (e.g., sea controls depend on vessel licensing), the utility of assessing control measures or strategies in isolation is questionable as benefits of control accrue from a suite of measures and cannot readily be allocated to any one control activity, or strategy.

Control assets are not necessarily allocated in the most cost-effective manner in relation to the presumed impact on the fish stocks, which is considered to be the primary object of control. While the principles underlying allocation of enforcement resources may be rational, the actual allocation may often be a response to changing 'political' priorities (e.g., resource conflicts), or a public

[30] Other management techniques can also be considered, e.g., zero-based budgeting and risk analysis. Environmental impact assessment requires placing monetary values on relatively intangible effects.

perception of the priority, rather than an empirical assessment of the optimum allocation in relation to the gravity, or extent, of the hazards to the resources. Consequently, attempts to make a cost benefit, or effectiveness analysis, often founder on the question of the allocation priority. However, cost effectiveness analysis may avoid such ineffective use.

**Cost effectiveness** analysis selects the set of MCS activities which will minimize costs while realizing the policy and operational goals, in other words, finding the least-cost solution to providing a given level of MCS. This approach is particularly useful. It requires the country (fisheries administration) to determine an 'acceptable level of violations' consistent with the paramount conservation objective. To determine and monitor this 'acceptable level of violations' requires a coherent set of indicators of effectiveness of and compliance. As in most policing work, the absolute effectiveness and benefit of an MCS system is difficult to measure. This is because the total number of violations is unknown. As a result the effectiveness of the MCS activities must be measured in relation to a set of common sense targets set by the fisheries authorities, possibly in association with the industry itself and the national planning agency, or budget office. Given that the quantity of the principal control assets and their operational costs (i.e., numbers of patrol vessels, or fisheries inspectors), are unlikely to vary greatly in the short term, indicators of their operational efficiency are of considerable importance.

**Table 5.1** : Possible indicators of MCS efficiency

| Offences/ violations | Patrols |
|---|---|
| Number of offences detected at sea | Hours/ days patrolled; Ratio air/sea hours |
| Number of offences detected on land | No. boardings; No. per patrol hour/day |
| Industrial offences | No. sightings; No. per patrol hour/day |
| Artisanal offences | No. catch/ net inspections (sea) |
| Major offences number and % | Hours per boarding |
| **Cost efficiency** | **Data efficiency** |
| Cost per 1 000 t or US$ million of fish landed | No. of logbooks checked* |
| Cost per log sheet checked | % of aerial position sightings checked with logbooks |
| Cost per boarding | Landings physically checked against |
| Cost per sighting | declarations Export declarations linked with dealer purchases |
| Cost per shore inspection | |
| Cost per VMS poll | |
| **Administrative efficiency** | **Casework efficiency** |
| Violation → report (% with 48 hours) | % of violations reported resulting in cautions/ warnings |
| Report → prosecution (% within 60 days) | % of violations reported resulting in prosecutions |
| Report → sanction (% within 30 days) | Success rate of prosecutions |

**Hazard analysis critical control point (HACCP).** Valuable lessons may be drawn from the HACCP approach Canada[31] is applying integrated fisheries management. The HACCP approach, which is already well known in relation to fish sanitary controls, simply acts as a framework to systematize the planning and organization of control activities. The main steps in the use of HACCP are:

- identify of hazards;

[31] See: Bevan, D. and D. Brock, 1999. Fisheries monitoring: A proposed Canadian model for an integrated conservation and management system (ICAMS). Int. Conf. on Fisheries Monitoring. FAO Rome, 1999.

- identify critical control points (CCPs) - locations, procedures and operational steps;
- establish limits to the critical parameters at CCPs;
- establish means of measuring and monitoring parameters at CCPs;
- identify corrective actions if limits are exceeded;
- document all procedures and record results; and
- periodically verify control measures.

The main threats and hazards to the fish resources are usually well known, e.g., violations which have the greatest impact on fish stocks. The critical control points are also known, but for various reasons may not be effectively used (e.g., lack of port inspectors, no factory gate checks, lack of authority to check dealer accounts). Many of the limits to the critical parameters are not codified, (e.g., there may be no standardized conversion factors for fish products such as 'fillet as percent live weight for particular species', shrimp 'tails to whole weight' for different size classes, or stowage factors 'kg per $m^3$'). The tolerance allowed when comparing log sheets to landings may be excessive. Penalties may not harmonize or be sufficiently specified in relation to the gravity of violations. Due to an absence of updated inspector manuals, different provinces, inspectors, or magistrates may interpret regulations differently. The annual reports required by the fisheries administration rarely make an assessment of the impact of fisheries control.

**Logical framework approach (LFA).** LFA is an objective orientated approach[32] used to design complex projects and often used to structure stakeholder dialogue to reach agreed solutions. The LFA is normally developed through a team of stakeholders progressively working through several steps: participation analysis, problem analysis, objective analysis, alternative analysis, determination of project elements, and external factors. The LFA produces three main outputs two of which are provided[33] here by way of a generic example: the problem and objective trees, upon which is based the logical framework matrix.

**Integrated fishery management plans**. The USA offers an example of a distinctly different approach to fishery management which includes the MCS component as an integral part of the fishery management plan[34]. The plan is approved through comprehensive legislation, which includes the budgetary provisions for its implementation, and evaluation. The essential point is that the costs of MCS are considered and budgeted prior to implementing management measures. The plan is a negotiated compromise settlement of stakeholder positions (including the fishermen) and 'losers' may receive financial compensation (e.g., for fleet reduction) to ensure their support for the plan. Decision rules may be included with linkages to biological or economic reference points.

**Value for money**. Finance ministries are becoming more concerned that government services provide 'value for money'. Joint civil/ military audits (e.g., for more cost-effective patrol), establishment of a 'value for money' committee, and realignment of budget sub-heads to reflect operational realities may contribute to improvement of the financial management and administration.

**Targeting**. A range of US and Canadian studies resulted in broadly similar recommendations on improvement of control effectiveness, including:

- targeting[35] chronic violators[36];
- concentrating enforcement measures on areas characterized by non-compliance;
- extending application of management measures to the post harvesting sectors;

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[32] See: NORAD, n.d., The Logical Framework Approach. ISBN 82-7548-002-7.

[33] [Not completed due to lack of time].

[34] NMFS, 1996. Magnuson-Stevens Fishery conservation and Management Act. As amended through October 11, 1996. U.S. Dep.Commer./NOAA Technical Memorandum NMFS-F/SPO-23

[35] Analysis of the boarding behaviour by two OECD countries indicates that boarding targets are essentially selected at random (approximately 90 percent of targets).

[36] Canadian studies show that five-ten percent of fishers tend to violate 'chronically and flagrantly'.

- substantially increasing the severity of penalties[37];
- ensuring input from enforcement authorities early in deliberations of new fishery management plans and regulations; and
- devoting resources to strengthen the use of non-coercive factors of compliance, such as social pressures, self-interest, inducement and obligation (fishermen sensibilisation/ education).

## 5.2 Nature of the benefits

Three types of benefits of MCS can be identified: direct, indirect and 'illegal'. The direct benefits are characterized by transfers, or payments made to the public sector through fines, licence fees, royalties and other charges. The indirect benefits of effective are characterized by the avoidance, or reduction of negative impacts characterized by:

- unauthorized foreign fishing and illegal trans-shipments;
- depletion of spawning and juvenile stocks and depletion of the fishable biomass;
- tax and levy avoidance and creation of opportunities for transfer pricing;
- increase in conflicts on the fishing grounds,
- undermining the rule of law and compromising aspects of coastal zone management and marine environmental protection;
- reduced profitability of fisheries, reduced economic rent and fleet efficiency, and less than optimal use of scarce national resources;
- declining levels of production reducing employment both at sea and on shore;
- additional direct costs of catching and handling illegal fish, and subversion of traceability and HACCP controls;
- costs of additional management and control measures resulting from stock decline; and
- reduction in legitimacy of management measures perceived to be based on inaccurate information.

The delinquent, or violating fisherman is likely to have an 'illegal' short-term benefit from breaking the fisheries laws (otherwise he is unlikely to violate). These gains are also measurable.

## 5.3 Direct benefits

In the Falklands approximately US$45 million was raised through the sale of fishing licences, while the total costs of fishery management was in the order of US$10 million in 2000. However, without the substantial expenditure on fishery protection, it is questionable whether the revenue would have been as high.

**Table 5.2 : Revenues associated with MCS activities during late 1990s in** West Africa

| | Gambia | Guinea | G. Bissau | Mauritania | Senegal |
|---|---|---|---|---|---|
| Value of landings 1996 (US$ million) | 19 | 19 | 38 | 140 | 212 |
| Licence revenues 1996 (US$1 000) | 285 | | | | 690 |
| Fines paid /owed (in US$100) /Year: 1997 | 247 | | 1 539 | 1 551 | 467 |
| 1996 | 6 | 460 | 1 525 | 1 963 | 810 |
| 1995 | 971 | | 150 | 1 652 | 676 |
| 1994 | 180 | | | 686 | |
| Licence revenue as % of value of landings '96 | 1.5% | | | | 0.3% |
| Fines as % of value of landings 1996 | 0.03% | 2.5% | 4.0% | 1.4% | 0.4% |

*Source: Kelleher, K. 1997*

[37] See: MRAG Ltd., 1993. This subject is further discussed below.

The amount of fines and compensation for violations received by FFA members was at least US$12.4 million[38] the 1978-2001 period. In the USA over US$10 million has been collected in certain years from fines and forfeitures. Major dealers[39] in illegally caught fish have been put out of business and numerous persistent offenders have been forced to leave the fisheries. Mauritania has covered more than 75 percent of its recurrent MCS expenditure from fines and penalties, but due to improving MCS expects this to reduce to less than ten percent within six years.

### 5.4 Indirect benefits

The primary operational objective of the MCS system is to enforce and support the management regime. The primary benefits of control accrue through improvement in the state of the resource, which is dependent on both natural and fishing mortality. Different control measures influence the fishing mortality in different ways, e.g., a violation concerning undersized fish will have a different biological effect from an over-quota violation concerning adult fish. In this manner, the management objectives and the nature of the control targets and regime determine the (biological) benefits derived from MCS activities. In principle these effects can be examined through simulations using a stock assessment model for the fishery and applying the compliance rates for each type of violation. However, uncertainty in biological models and the assumptions required regarding compliance levels makes calculation of marginal benefits of control extremely problematic, even for a simple regime. Estimating the aggregate benefits of control for a set of management measures impacting on several different fisheries represents an even greater challenge. In practical terms, fisheries scientists often assume 100 percent compliance, or make subjective assumptions regarding compliance.

This problem simply illustrates the need for management measure to be 100 percent enforceable[40] in order that their effects can be measured, and reinforces the need to simplify regulations, and to promote cost-effective, aggregate, or concentrated controls such as closed areas, VMS, and fish dealer and auction checks.

Effective MCS provides accurate catch and effort information essential for stock assessment[41]. Misreporting of catches initiates a 'vicious circle' of hidden costs from a reduction in the accuracy of stock assessment and thereby undermines the biological basis for management measures and their adequacy. According to ICES[42] it is not possible to retrospectively estimate misreporting accurately.

### 5.5 Fishing the benefits of illegal

Most of the research on the benefits accruing to fishermen from illegal fishing has been carried out in OECD countries. Annual potential losses from a projected sustained withdrawal of US Coast Guard patrols in the Bering Sea and resulting from increased incursions by foreign vessels targeting pollack

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[38] FFA VAP database (which does not contain complete information).

[39] E.g., in 1999, the NOAA charged a Fulton Fish Market retail dealer with 172 counts of violations that undermine rules designed to protect and conserve New England ground fish stocks. The dealer faced permit suspension and penalties of 1.7 million for allegedly concealing or falsifying the purchase of hundreds of thousands of pounds of fish from at least 23 fishing vessels over a year-long period.

[40] The ASMFC Law Enforcement Committee, 2000. Guidelines for resource managers on the enforceability of fisheries management measures. Internal report.

[41] E.g., "ICES expressed the greatest possible concern in past AFCM advice over the quality of catch and effort data from most of the important fisheries in the ICES area. ICES stressed that the immediate consequences of this are that ICES will be unable to provide reliable estimates of current stock sizes and forecasts that have been used to set TACs." ICES Cooperative Research Report No. 236 (AFCM). 1999.

[42] Pers. comm. ICES staff. Though retrospective modelling can reconstruct the state of a stock, it is not possible to separately attribute the influences of past environmental factors and species interactions from previous misreporting.

have been estimated[43] at between US$6.7 million and US$40 million. Further losses from rising international tension and conflicts on the fishing grounds could also be expected. Estimates[44] of the value of illegal catches in the US Northeast ground fish fishery ranged from one-two percent of the value of landings in one area to 11-25 percent in another, indicating wide variations by State and fishing ground. A study of five OECD countries indicated that the value of the benefits from illegal fishing was up to eight times greater than the cost of MCS and that between six percent and 22 percent of fishing activities were non-compliant.

**Table 5.3** : Estimate of the value of illegal fishing activities in the SRFC area in mid-1990s

| Calculation | Value | Reference |
|---|---|---|
| Estimated total recorded catches in SRFC area | 1 273 000 tons | CECAF |
| 11% of all sightings are illegal fishing operations | 11% | AFR/010 |
| 91% of all illegal fishing operations are serious infractions | 91% | AFR/010 |
| Assuming illegal catches are unrecorded | 100% | assumption |
| Estimated quantity of illegal catches | 127 000 tons/year | |
| Estimated average value per ton of fish (1994)* | US$1 300 | |
| Possible value of illegal catches | 166 million US$/year | |

* Average value of Senegal trawl fish in 1994 (most illegal fishing is trawling).

Based on records of aerial surveillance, the following is a relatively simplistic estimate of the value of illegally caught fish in the SRFC area. It does not take into account that illegal fishing tends to target higher value species, or that catches fished illegally in one country may also be recorded as 'legal' landings in another country.

## 5.6 Deterrence, compliance and benefits

There is a close relationship between deterrence, compliance and the perceived benefits from illegal fishing. A number of studies in OECD countries have examined these relationships. The approaches and results are of interest to those designing MCS systems in developing countries.

Estimates of compliance require an estimate of the total number of violations. None of the approaches used to estimate the absolute, or total level of violations is entirely satisfactory. The analysis of recorded violations in relation to control efforts is routinely used to provide an indicator[45] of the level of violations, though such information is a measure of the outputs of enforcement, rather than the level of violations. Surveys of fishermen have been used with mixed success[46] and form the basis for most studies to date. However, such surveys cannot be conducted on a regular basis, and as the subject matter is of a highly sensitive nature, results may be largely dependent on the design of the survey and skills of the interviewer(s).

Consequently, estimates of compliance require certain assumptions. Extrapolation of a compliance estimate from one type of offence to another, and from one fishery to another requires additional assumptions. Measurement[47] of the effects of controls on compliance requires both a known change in the level of enforcement efforts and a corresponding knowledge of the resulting compliance.

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[43] IDA study.

[44] Sutenin, Reiser and Gauvin, 1990

[45] Detected violations may be a relatively small sample of fisherman behaviour, and may not be statistically valid. Not all violations are necessarily detected by a control operation (e.g., during a boarding a fishery inspector may not find the box of undersized fish).

[46] See Furlong, W.J., 1993. Enforcement effectiveness study. Report 4. Dept. of Fisheries and Oceans, Canada..

[47] Only the IDA study in the USA has analysed a time series to enable calculation of a marginal increase in compliance of one fewer violation per 4.6 boardings.

**Models of compliance**. A series of reports[48], focused largely on the Northeast region and Eastern Canada, developed models[49] of delinquent fisheries behaviour and the economics of fisheries enforcement. The models identified three main factors influencing compliance and deterrence:

- the level of the expected penalty and probability of incurring the penalty;
- the moral attitude of the fisherman, in particular his perception of the legitimacy of the regulation;
- social influence, particularly[50] through other fishermen.

Fishermen may not consider certain fisheries regulations to be legitimate[51]. Consequently, the fisherman does not consider he is doing a moral wrong when violating such regulations and the balance of peer opinion may support this moral position of the fisherman.

The level of penalties is often inadequate[52] as a deterrent and can be regarded simply as a 'cost of doing business'. Given that the probability of detection of offences at sea cannot easily be reduced in a cost effective manner, effective deterrence may require substantial increase in the severity[53] of penalties. If both the probability of detection and subsequently paying a penalty is so low that it is not a deterrent, either the penalties must be increased, and/or the regulations changed to make them more enforceable. The following table are based on actual OECD country studies of compliance and deterrence and illustrate these points.

**Table 5.4** : Summary deterrence indicators from sea patrols in an OECD country

| Indicator | Value* |
|---|---|
| % of vessels boarded each year | 31 |
| No. of vessels boarded per patrol vessel day | 2.2 - 3.6 |
| Correlation coefficient patrol vessel days and boardings ($r^2$) | 0.65 - 0.81 |
| Monthly boarding rate range (boardings/no. vessels) | 0.05 - 0.65 |
| Peak boarding period/ peak fishing period | Oct-Nov / May-June |
| Probability of a violator being boarded | 0.23 - 0.39 |
| Probability of a violation being detected, assuming boarding detects 50% of violations | 0.12 - 0.22 |

[48] Refer to bibliography - papers by Furlong, Sutenin, and IDA (Crane/ Warner/ Kuchma).

[49] The models have become progressively more sophisticated. Andersen and Sutenin's 'economics of fisheries enforcement' was based on Becker, 1968. Furlong (various Canadian papers) tested this deterrence model based on the idea that expected penalties should exceed illegal gains for effective deterrence. Mixed results from studies led to the introduction of two further parameters reflecting firstly, the influence of the fisherman's moral obligations and perceived legitimacy of the regulations, and secondly, the social pressure to comply.

[50] And also the attitude of the enforcement agencies, i.e., treating fishermen with respect rather than suspicion. See: Hønneland, G., 2000.

[51] For a discussion of legitimacy see Hønneland, G. 2000. Compliance in the Barents Sea fisheries. How fishermen account for conformity with rules. Marine Policy, vol. 24, 2000. In general the social base is stronger than deterrence (Kuperan and Sutinen 1998). Fishermen operating in Irish waters lack a coherent social base as they are distributed throughout several Member States with differing social structures - i.e., there is no 'community' and such community pressures cannot exist given the present centralised structure of the CFP. Thus the fallback to the less effective deterrence basis of control. The 'Green' lobby may emerge as a useful 'common denominator' building a community ethos for conservation advocacy (e.g., IUCN, Greenpeace, MSC, and others).

[52] This can be shown empirically - see papers by Furlong, Sutinen et al.

[53] Deprivation of fishing rights on a temporary, or permanent basis has been found to be a particularly effective penalty. Some countries have a schedule of escalating civil penalties for repeated offenders.

| | |
|---|---|
| Probability that a case (arrest/ prosecution) will be dismissed | 0.14 - 0.20 |
| Probability that a fine/penalty will accrue in a case | 0.42 |
| Probability of monetary penalty given a violation detected | 0.04 - 0.08 |
| Average value of fine/ penalty (excluding legal costs to fisherman) in 1995 | US$4 934, median US$1 348 |

* Probabilities expressed as decimals

**Table 5.5** : Estimating* the probability of being penalized for a violation at sea in an OECD country

| | |
|---|---|
| **Sampled vessels** | |
| Average number of fishing days/yr | 257 |
| Perceived average boardings/vessel/year (from interviews) | 4 |
| Probability of being boarded/day (from interview/ MCS records) | 1.56% |
| **All vessels** | |
| Total fishing vessel targets/day (av. of samples from high level radar)*...(a) | 195 |
| Boardings per patrol day (1999) .....(b) | 0.98 |
| Probability of being boarded/day (all vessels) (b/a) ..... .....(A) | 0.5% |
| Probability of detection of violation per boarding (from MCS records) | 15% |
| Probability of detention (arrest) at sea.....(B) | 3% |
| Probability of penalty if detained (ratio prosecutions/ penalties).....(C) | 66% |
| Probability of paying a penalty in a given fishing day .....(A*B*C) | 0.01% |

*Actual example from an OECD country

# ANNEX 1

# TECHNICAL AND COST DETAILS

## 1. Indicative capital costs

**Table A1-1** : Scale of capital assets required for various MCS activities

| Fishery | | Indicative level per unit | | |
|---|---|---|---|---|
| Type | Unit size | Asset | No. and size | Shore inspectors |
| Artisanal | 100 canoes | Inshore vessel<br>Community agent | 0.25 x 7-10 m | 1<br>2 |
| Artisanal | 100 motorized | Inshore vessel | 0.5 x 10 m | 2 |
| Semi-industrial | 100 (10-20 m) | Coastal vessel | 0.25 x 20 m | 1-2 |
| Coastal industrial | 100 (20-35 m) | Coastal vessel<br>Small aircraft | 1 x 20-25 m<br>1 x 2-4 patrols/ week | 10-15 |
| Offshore industrial/ foreign fleet | 100 (25-50 m+) | Offshore vessel<br>Small aircraft<br>Observers<br>VMS | 1<br>1 x 2-5 patrols/week<br>0.25-2 per vessel<br>1 per vessel | 10-15<br><br>50-200 |

*Source: SADC MCS Feasibility study*

**Table A1-2** : Summary of indicative costs of capital items

| Item | Description | Cost US$ | Reference |
|---|---|---|---|
| **Offices and office equipment** | | | |
| HQ building | Regional surveillance office | 60 000 | Gambia |
| Field office | | 20 000 | |
| Village 'office' | Local materials with tin roof | 700-2000 | E. Africa |
| Solar panels for radio | | 1 000 | |
| Diesel generator | | 2,000 | |
| Photocopier | | 1 500-5 000 | |
| Computer with printer and software | | 2 500 | |
| Fax machine | | 200-300 | |
| Mobile telephone | | 30-150 | |
| **Vessels and vehicles** | | | |
| Military patrol vessel | New, EU built 50 metres | 25 million | Ireland |
| Modified fishing vessel | Cost of modifications 1.5 million | 2 million | Angola |
| Offshore patrol vessel | 25-32m estimate FISHCODE project | 5 million | SE Asia |
| Inshore patrol vessel | 18-20m estimate FISHCODE project | 500 000 | SE Asia |
| Coastal/ inland | 6-8m GRP with trailer | 10 000 | SE Asia |
| RIB semi-rigid with trailer | 9m, 2 x 100 hp radar, radio, GPS, armed, | 30 000 | S. Leone |

| Item | Description | Cost US$ | Reference |
|---|---|---|---|
| 4 Wheel-drive | Toyota pick-up, Land rover | 25-35 000 | West Africa |
| City vehicle | 4-door, 1,200 cc | 10-12 000 | E. Africa |
| Motorcycle | 50-175 hp | 1 000-2 500 | E. Africa |
| Bicycle | Imported | 100-150 | East Africa |
| Local wooden boat | | 200-600 | E. Africa |
| Local canoe | | 75-120 | E. Africa |
| **Aircraft: see separate table** | | | |
| **Electrical / communications equipment** | | | |
| Radio | VHF | 250-600 | EU |
| Radio | SSB/ HF radio | 290 | |
| Radar | 10" LCD - 15" LCD/TFT | 3 200-6 000 | EU |
| Telephone | installation cost | 20-150 | |
| Cell phones | various local range | 20-120 | S. Africa |
| Wakie-talkie | | 100-150 | |
| GPS | hand-held | 100-600 | EU |
| EPIRB | Tron 45S | 600 | |
| Digital camera | pocket | 500-900 | |
| Digital SLR camera | SLR for aircraft w/ GPS attachment | 5-6 000 | West Africa |
| Video camera | 700-1400 | | |
| RIB tracking system | | 254 000 | EU |
| Electronic chart system | | 381 000 | EU |
| Night ID equipment | Airborne infrared lights and camera | 317 000 | EU |
| **Miscellaneous equipment** | | | |
| Charts | marine | 20-50 | EU |
| Scales | hand held | 10-20 | EU |
| Calculator | pocket | 5-20 | EU |
| Fish measuring board | | 15-30 | SE Asia |
| Net gauge | brass | 40-75 | SE Asia |
| Binoculars | | 200-300 | SE Asia |
| Binoculars with night vision | | 1 700 | SE Asia |
| Loud hailer | | 100 | EU |
| Uniforms | | 40-80 | W. Africa |
| Life jackets | | 25-50 | SE Asia |
| Survival suits | | 200-300 | EU |
| All weather clothing (waterproof) | Waterproof pants/ jacket | 200 | EU |
| Waterproof flashlights | | 30 | SE Asia |
| Floodlights for patrol boat | | 400 | SE Asia |
| Destructive fishing detection | Laboratory and equipment | 300 000 | Philippines |

## 2. Technical descriptions of selected capital assets

**Table A1-3** : Technical description and cost of long-range maritime patrol aircraft

| Manufacturer/ aircraft | CASA/ CN 235 | Lockheed Martin/ P3-Orion |
|---|---|---|
| Engines | 2 x GE CT7-9C delivering 1 750 SHP each | |
| Speed | Cruise 220 knots, patrol 180 knots | Cruise 378 mph (610 km/h). Patrol 473 mph (760 km/h) |
| Maximum take-off weight | 15 800 kg | Empty Weight: 61 491 lb. (27 890 kg) |
| Maximum altitude | 25 000 ft | 28 300 ft. (8,630 m) |
| Maximum endurance | 10 hrs | 4 765 miles (7 670 km) |
| Radar systems | Litton V5 360° scan with Tactical Data Management System | |
| Radar specs. | 150 nm at 15 000 ft; 47 nm at 1 500 ft; 25 nm at 200 ft. | |
| Communications | HF and Data Link (under review) | |
| Cameras | Infra-red; Agi flight (still) camera linked to GPS | |
| Data base | Lap-top with land updated information | |
| Crew (6) | Captain and co-pilot; radar operator and assistant; photographer, observer | |
| Cost (1994) | US$21.5 million | |

**Table A1-4** : Indicative costs of patrol aircraft (US$)

| Aircraft type | Key characteristics | Capital cost (million US$) | Operating costs/yr (million US$) | Per air hour (US$) |
|---|---|---|---|---|
| Cessna 412 | | 2 | 0.5 | 400-800 |
| BN Islander | | 2 | | 700-1 000 |
| Twin Otter | | | | 1 000 |
| Dornier 228-212 | Operational speed: 290 km/h Service ceiling: 20 700 ft (6 300 m).Range: 667 n miles (1 235 km). | 5 | 2 | 1 200 |
| Beech craft | King Air turbo | 6.2 | | 1 400 |
| CASA CN 235 | see above | 21.5 | | 2 000-3 000 |
| P3 Orion | Long range | | | 3 000 |
| HC-130 Hercules | Standardized hourly operating costs of Coast Guard aircraft in USA | | | 7 497 |
| HU-25 Guardian | | | | 5 418 |
| HH-60 Jay hawk | | | | 6 235 |
| HH-65 Dolphin | | | | 3 910 |

| Box 2. Specification for the inshore patrol vessels supplied to Yemen |
|---|
| Unit cost delivered to Yemen: **US$48 500**<br>Supplied by: Government of Japan<br>Construction:<br>GRP single skin sandwich with wheelhouse and passenger seating.<br>Rubber D-fenders and stainless rails. Rubberized matting floor<br>Length overall: 10.12 metres. Beam(breath): 3.20 metres. Depth at midships: 1.75 metres<br>Gross tonnage: 18 tons approx. Complies with international classification<br>Engines: 2 x outboard 200 hp (5500 rpm) Cruising range: 130 n.miles approx.<br>Speed fully loaded (fuel, water and 17 persons): 26 knots<br>Fuel (gasoline): 800 litres. Water: 200 lit approx.<br>Passengers: Crew 2 & seating for 15 persons<br>Electrical fittings:<br>Generator AC 220v x 50 Hz, DC 12v x 10A<br>SSB radio telephone 150w Furuno FS1502, VHF radio telephone 25w Furuno FM 25100<br>GPS Furuno GP8000. Depth sounder FCV 561 Mark II. Magnetic compass. Marine Radar 36<br>Electric horn/ siren, search light, flashing light and navigation lights<br>Other fittings: Life raft, life jackets, first aid kit, life buoy, fire extinguisher, mooring ropes, Dan forth anchor, service manuals |

## 3. Selected recurrent costs and budgets

**Table A1-5** : Breakdown of operating costs of the Fisheries Patrol Vessel N'Madi (Mauritania) in 1995

| Item | No. units | US$'000 | % | % |
|---|---|---|---|---|
| **Personnel** | | **78 908** | **7.5** | **100** |
| Senior officers salaries | 2 | 6 277 | | 8 |
| Junior officers salaries | 15 | 34 615 | | 44 |
| Seamen salaries | 8 | 11 077 | | 14 |
| Uniforms (officers) | 34 | 22 754 | | |
| Uniforms (seamen) | 16 | 4 185 | | |
| **Operating costs** | | **360 469** | **34.5** | **100** |
| Diesel fuel | 1 | 144 377 | | 40 |
| Oil | 1 | 36 354 | | 10 |
| Petrol | 1 | 11 085 | | 3 |
| Water | 1 | 3 546 | | 1 |
| Food | 1 | 43 792 | | 12 |
| Maintenance items | 1 | 6 331 | | 2 |
| Minor (in-house) repairs | 1 | 50 738 | | 14 |
| Miscellaneous | 1 | 64 246 | | 18 |
| **External (major) repair/ maintenance** | 1 | **553 846** | **53.0** | |
| **Insurance** | 1 | **51 923** | **5.0** | |
| **Total (excluding depreciation)** | | **1 045 146** | **100.0** | |

**Table A1-6** : MCS staff salaries in Namibia 2001 (US$)

| Level | US$ | Overtime as % total |
|---|---|---|
| Level 1. Control Fisheries Inspector: | 10 417 | 19 |
| Level 2. Chief Fisheries Inspector: | 15 393 | 47 |
| Level 3. Senior Fisheries Inspector: | 12 230 | 46 |
| Level 4. Fisheries Inspectors: | 10 933 | 49 |

**Table A1-7** : Standardized hourly operating costs of US Coast Guard vessels

| Sea patrol vessel type | US$/hour |
|---|---|
| 378' High Endurance Cutter (WHEC) | 5 464 |
| 270' Medium Endurance Cutter (WMEC) | 3 275 |
| 210' Medium Endurance Cutter (WMEC) | 2 839 |
| 82 - 110' Patrol Boats (WPB) | 1 015 |

The estimated cost per boarding is in the order of US$15 000 (depending on the size of the patrol vessel). Using this value and based on IDA estimates the marginal cost of deterrence by boarding is in the order of US$65 000, i.e., 1 fewer violation per 4.6 boardings.

**Malaysia's MCS system.** Malaysia has a well-developed MCS system with 85 patrol vessels of various types and sizes[54], 1,152 MCS staff including boat crews with (approximately 280 being in the officer/management category), and a computerized fisheries licensing system (on-line in the states and districts and once/24 hr download to HQ). The fisheries administration is seeking ISO 9000 certification for the system.

**Table A1-8** : Malaysia's MCS budget (RM thousands)

| Operations | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|
| Staff | 8 538 | 7 740 | 8 508 | 6 638 |
| Operations and maintenance | 4 406 | 1 735 | 2 287 | 2 250 |
| Development and replacement of assets | 5 502 | 3 495 | 3 021 | 8 385 |

Notes: Development includes equipment replacement. The economic situation resulted in very significant cuts in budgets, no recruitment and no maintenance and minor equipment replacement from 1997 to 2000.

[54] Patrol vessels: 4 x 200 Series 27 m 27 knots; 4 x 100 Series 21 m 24 knots; 5 x 300 Series 17 m 25 knots; 17 x PA Series 12-17 m 24 knots; and 55 x PL Series 6-9 m 35-40 knots.

## 4. Violations in the FFA and SRFC areas by type of violation

**Table A1-9** : Breakdown of violations recorded in the FFA area by type of violation and vessel

| Violating vessel | Number | Percentage |
|---|---|---|
| Longline | 198 | 62 |
| Purse Seine | 84 | 26 |
| Fish Carrier | 14 | 4 |
| Trawler | 13 | 4 |
| Mother ship | 2 | 1 |
| Supply Vessel/ Bunker | 4 | 1 |
| Pole- and- line | 1 | 0.3 |
| Net Boat | 2 | 1 |
| Search/ Light | 1 | 0.3 |
| **Total** | 319 | 100 |

| Type of violation | Number | Percentage |
|---|---|---|
| Illegal fishing | 203 | 64 |
| Breach national law | 30 | 9 |
| Licence non-compliance | 84 | 26 |
| Breach international law | 2 | 1 |
| Total violations | 319 | 100 |

Note that the focus of FFA efforts is the non-domestic flag tuna fishing vessels.

**Table A1-10** : Number of arrests by type of violation in SRFC countries in 1997

| | Gambia 1997 | Senegal 1997 |
|---|---|---|
| No license | | 12 |
| Fishing in prohibited (artisanal) zone | 11 | 24 |
| Trans-shipment | | 0 |
| Illegal mesh | | 3 |
| Other | | 11 |
| Total | 11 | 50 |

**Table A1-11** : Violations recorded by aerial surveillance by type of violation in 1997

| Type of violation | Gamb. | Guin. | G. Bis. | Maur. | Sen. | S Leo. | Total |
|---|---|---|---|---|---|---|---|
| Licensed vessel fishing in prohibited zone | 9 | 14 | 4 | 28 | 2 | | 57 |
| No valid licence | 38 | | 78 | | 5 | 4 | 125 |
| Identification marks (covered/non-existent) | 1 | 448 | 22 | | | 4 | 475 |
| Violations as % of sightings | 8% | 19% | 59% | 9% | 4% | | 11% |

*Source: AFR/010 database to Nov. 1997. Gamb = the Gambia; Guin = Guinea; G. Bis = Guinea-Bissau; Maur = Mauritania; Sen = Senegal; S. Leo = Sierra Leone.*

## ANNEX 2

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**Note: In certain instances where materials are drawn from internal government documents the sources are not cited.**

## ANNEX 3

## TERMS OF REFERENCE

1. Assess the costs generally involved in fisheries monitoring, control and surveillance.
2. Examine the particular situation of some developing countries with regard to MCS and its support to fishery management.
3. Present estimates of the capital and recurrent costs of different components of MCS systems.
4. Analyze effectiveness and benefits of different MCS systems in particular in developing countries.
5. Write a report entitled "Study into the cost of MCS" which would be suitable as a contribution to a "Guidelines on systems for cost-effective monitoring, control and surveillance of fisheries".

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